STREET PATTERNS
AN ANALYSIS AND EVALUATION

by

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PRINCETON UNIVERSITY

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PREFACE

The idea for this thesis came after I had considered and rejected many other subjects; subjects which would have fit into the limited time and resources available to me far better than this one. But this subject posed such a tempting and interesting challenge, that I chose not to ignore it. My curiosity was aroused by the rich variety of patterns that appear in cities; why there were differences and similarities, and what these patterns mean for the cities they serve.

Though there are countless writings on urban subjects--city planning, city history, urban sociology--none of them seems to deal intensively or extensively with this question. There are likewise almost unlimited numbers of studies, books and articles on traffic engineering, highway location and design, and transportation science, but these are colored by their preoccupation with the movement of vehicles as the final goal. There appeared to be a knowledge gap that could be filled by a study of streets patterns that considered them historically and functionally; that would deal just with streets, but would combine an analysis of their esthetic, economic and traffic characteristics.

This is a broad subject. It is too broad for the properly intensive study that should be provided. However, it was undertaken

primarily as a material-gathering and synthesizing project, and not as an attempt to unearth new material. Though much must be omitted when breadth is substituted for depth, it is hoped that this imperfect framework, can bring some appreciation for the complex question of street patterns. This is an important and comprehensive subject in itself rather than an incidental part of the study of cities.

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AN INTRODUCTION

A brief account of the history of cities and streets, with emphasis on how the evolution of transportation has affected them. A discussion of the functionality, the cost, and the appearance of streets, stressing the necessity of a concern for all three. An examination of the kinds of spaces that men live and travel in in cities.

CHAPTER ONE

CITIES AND STREETS

A city, at the very least, is a composition of buildings and streets. It is usually many things more, of course, but these are the essential physical elements. The buildings provide shelter and the streets allow for circulation, both of which are necessary for human life to exist. Men have constructed this artificial environment in a manner such that shelter, movement, and all the other vital institutions and functions of life are preserved. This material milieu of man's own making has taken various forms. Its size and organization have differed greatly from time to time and from place to place. Although all cities are alike in many respects, they are also obviously all different. It may be that their likenesses and variations are rationally based, reflecting good reasons for the similarities and the varieties found in city patterns. Economy, efficiency and beauty may account for the design of cities, forging out their best products from whatever assets and circumstances are at hand in each particular case. On the other hand, city-formation may be the result of chance, custom, and habit, reflecting on a superficial logic. Tradition and ideology, rather than reason and science, may be the well-springs of city forms.

The evidence about us seems to indicate that both sense and nonsense play a part in shaping cities. Men build cities that work, yet they work imperfectly. Taken individually or collectively, they are only partially successful in serving men's purposes. Cities are largely products of a trial and error process, it appears. They are reactionary creations. Yet, within reaction there can be incremental change--even foresight, perhaps. This is fortunate, because change is a fact--a relentless force--with which men must reckon, and their artifacts should be able to respond in stride. Viewed in this light, the problem is partly one of determining that variety--that form of the physical city--that has the most adaptive structure. Which city pattern is the most responsive to the changing needs and functions of men?

One feature of the world of change is the evolving nature of movement. The transportation of men and materials has undergone a series of profound and radical transformations since cities began. The element of the city which bears a major impact of such changes is the street system. Ironically, the street is the most permanent physical structure of the city. A street once located is rarely moved or abondoned, save for the death of the entire city. Buildings burn, fall and are torn down. Whole neighborhoods change and change again, but streets survive. Figure 1 shows how part of a city may change in character almost completely over the years, and yet retain the same street pattern. Streets are rooted, literally and figuratively, on their

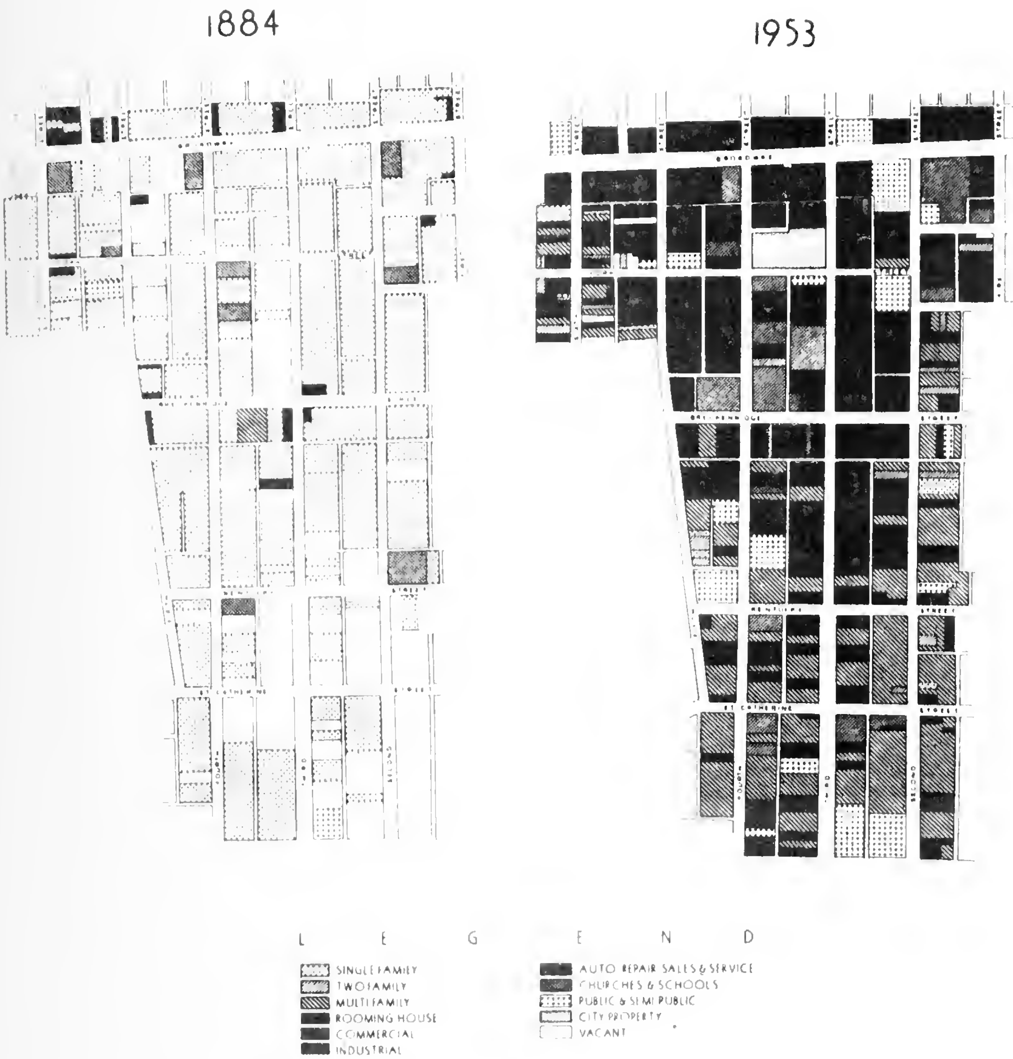

Figure 1.

Permanence of the street pattern with changing land use, Louisville, Kentucky. [From Harland Bartholomew, Land Uses in American Cities, (Cambridge, Mass.: Harvard University Press, 1955), p. 12, PLATE II]

sites, by utility lines, property lines and by custom. Few cities of the world, even those destroyed by war or natural disaster, have managed to alter significantly any major portions of their original street patterns.[1] Even today, as bulldozers execute the will of urban renewers on an unprecedented scale, the street systems tend to remain intact. In a sense, streets are almost stillborn. The unyielding nature of streets--their endurance and rigidity--makes their inception a vitally and absolutely important step. This means that their initial plan cannot be attuned only to the immediate objective and the current use, but must be flexible enough to allow some response to evolving needs. This is far easier said than done, to be sure. It may be well, too, to examine the validity of these "needs" to be certain that they are inseparably associated with the real reasons for the city's existence. There must be unity of purpose among all the parts of the city. The unilateral modification of one functional element, or one physical form, as a result of technological ability to do or to build that one thing better, might not be in the best overall interest of the city. Builders of cities, then, should have a vision of what is to come, but also a knowledge--a conviction--of those things that should remain, as well.

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1. Examples of the inability to change street locations in bombed-out cities of World War II are cited by Fred C. Ilke in "Reconstruction and Population Density in War-Damaged Cities", Journal of the American Institute of Planners, XVI, Summer 1950, p. 131-139.

The origins of human routes are too remote in time for discovery. Paths and roads probably predate cities by many millenia, while streets are as old as the earliest tiny settlements. Cities themselves date to several thousand years before the birth of Christ, there being clear evidence of urban formations--not just agricultural or nomadic villages--as far back as 3500 to 4500 B.C.[2] The streets in these early cities generally were not planned at all, but were rather mere connected open spaces left between buildings in order that men could move about, conducting their minimal affairs. Circulation, by later standards, was quite modest. Men were only partially interdependent and specialized, and they needed access to only a handful of places and other persons in order to live a normal, complete life. People of the preindustrial city probably had a casual attitude about their streets. Cities were small, and the streets were not heavily burdened by the circulation of the population.[3] Meager food surpluses, and the lack of a means of transporting great quantities of them to cities, limited city growth. Under such conditions the street

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2. There is disagreement on the dates of the first cities, but this appears to be more a matter of definition of the city rather than assignment of age. There seems to be agreement that cities are at least this old. See Gordon V. Childe, "The Urban Revolution", The Town Planning Review, XXI, April 1950, pp. 3-17.

3. Only twelve cities had populations of 100,000 or more in the Mediterranean area at the beginning of the Christian era, according to Amos H. Hawley, Human Ecology, A Theory of Community Structure (New York: The Ronald Press Co., 1950), p. 371.

served as an open space in which to work, to play, to mingle and socialize as well as an avenue on which to circulate. Practically all movement within the ancient city was done on foot, with animal-powered transportation being restricted to the few main thoroughfares leading into the city.[4] As a consequence, street patterns which were suited to the pedestrian developed. Traveling space consisted of a series of narrow, winding alleys. Buildings arose on every available space in the larger cities in order to provide protection behind the city's wall for the maximum number of persons, and for reason of economy and good access, in terms of travel-time, to other parts of the community. The spaces for circulation were reduced to the minimum required.[5]

In time, agricultural methods improved and cities accordingly grew in population. Their area grew, too, but not in proportion to population, because pedestrians still predominated in intra-city movement. By the beginning of the eighteenth century, 146 cities had attained populations of 100,000, but they were still spatially of small or moderate size.[6] Density, in other words, was on the rise. Building heights increased and so did occupancy rates, with an attendant growth of traffic as a natural consequence. By this time street layouts

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4. Charles M. Robinson, The Width and Arrangement of Streets (New York: The Engineering News Publishing Co., 1911), p. 46.

5. Gideon Sjoberg, The Preindustrial City (Glencoe, Ill.: The Free Press, 1960), pp. 91-93.

6. Hawley, op. cit., p. 372.

were becoming more and more the results of conscious action, instead of natural developments. Street planning had been practiced from the very earliest city periods, but it was only after the Middle Ages in Europe that it was widespread.[7] However, the planned efforts were not unlike their unplanned counterparts in width and extent. Straight streets, right-angle intersections and predetermined patterns made a difference, but it was largely just a visual difference for this still nonmotorized age. Later, the introduction of a few wide boulevards in the Baroque city served as an effective physical and spiritual relief valve for the thickening, stirring masses.

These, then, were the conditions existing in city streets for many centuries until the advent of the Industrial Revolution, or mid-eighteenth century. Traffic conditions were satisfactory on the whole, though there were definitely cities and places within cities that suffered terrible congestion. Paris, for example, was quite crowded, and its streets were not the safest places in town. But one's pace and range were not seriously limited by the street network, and one's nerves were not severely stressed by city travel, even though circulation may have been cramped in places. Congestion existed, to be sure, but for the most part it was likely nothing worse than that of present-day city

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7. Thomas Adams, <u>Outline of Town and City Planning</u> (New York: Russell Sage Foundation, 1935), pp. 33-77.

sidewalks on an average day at ten in the morning. This is not to say that there were not other problems, and serious ones, in the ancient and Medieval cities, such as poor sanitation practices, but traffic at least was functioning at a tolerable level of efficiency.

Of course this condition did not last. While men were urbanizing, they were also altering many other aspects of their lives, including transportation. This sphere of life made its imprint on cities in two ways: As an external stimulus and as an internal disturbance. Progress in the field of land transportation has carried man first from the use of his legs exclusively, through the employment of animal-power, and into the age of mechanically powered vehicles. Each successive stage in this fantastic saga has added to his city-building potential. But it was not until movement was freed from the limits of animal power that a break-through in speed--and in city size--was realized. And only after a means of replacing men's legs with individual vehicles was developed, was accelerated speed, coupled with personal control, to challenge the old city and street patterns in undeniable terms.

Steamboats and railroads were the external stimuli, but the automobile was the internal disturber. The electric trolley's transient existence contributed in both these ways, to some extent. The innovations in inter-city and inter-urban transportation methods contributed to increased traffic on the city's streets, but did not change the fact that a large share of a person's and a city's movement remained

pedestrian. Furnishing a revolutionary intra-city mode of transportation was the automobile's task. The freedom and speed with which the automobile could move was the novelty which enabled the city to grow omnidirectionally instead of just along the narrow thoroughfares of previous eras. So, under the influence of new transporting agents which covered the spectrum from individual to massive movements, cities grew briskly, traffic grew even faster, and new forms of "life" entered the streets.

Men were not content to use their newly invented devices for just inter-city or inter-community travel, but insisted on bringing them into the hearts of the city. The automobile appeared to be the all-purpose vehicle. However, by the time that this cheap, flexible mode of transportation became commonplace, cities were already cast in a more modest scale and pattern. "Hardening of the arteries" had already set in.[8] The streets were immovable objects, being confronted with what appeared to be irresistable forces and the "insolent chariots" moved in.[9] It was natural that there should be conflict here. Automobiles and trucks were big, hard, fast and purposive. Streets were

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8. See Raymond Vernon, <u>The Myth and Reality of our Urban Problems</u> (Cambridge, Mass: Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University, 1962), p. 7.

9. The term is taken from John Keats' critical and entertaining book about Detroit's products, <u>The Insolent Chariots</u> (Philadelphia: J. B. Lippencott Co., 1958).

small, their occupants soft and slow. Streets, the spaces previously considered the domain of air, light, and activity of a yielding, give-and-take nature, became the home of inhuman and unbending objects. It seemed logical at first to use these machines at will. Having found an ultimate mode of travel, it would have been foolish not to have used it, men reasoned. This attitude was not challenged, and so the automobile moved in, never yet to be dislodged. Some city forms were more susceptible to this invasion than others. They were apparently the adaptive types--able to accommodate change. But a second look puts this thesis in grave doubt. Possibly the patterns of most resistance were the most far-seeing of all, it is now concluded. This issue is still in doubt.

Because of the effects of technology, transportation, and automobiles in particular, men began to do something about the state of their cities. It was far too late to find an easy remedy for the situation in the old cities. They could not be saved _en masse_. But at least the new parts could be better built. It was clear that the automobile could not effectively and entirely replace the pedestrian in the patterns of the old cities, so new cities would have to be built differently. Men did not seem to consider the alternative solution to the problem.

Streets and communities of the new era could have been planned on the old scale, retaining the old patterns, barring the motor vehicle from pedestrian areas. In other words, the desire to replace walking

with riding at all levels down to the very shortest outside travel distances could have been thwarted. Auto use could have been permitted to penetrate the pedestrian sphere only so far, beyond which human motive power would have remained as the principal means of movement. On the other hand, a complete, or almost complete, replacement could be allowed, with motor vehicles taking over as much of the individual movement function as it was able to. This is essentially the path that has been followed, and the patterns of modern suburban communities are derived from this decision, or capitulation, as it sometimes appears. The modern city is totally committed to the full scale use of the automobile. And even the old city, under the pervasive-use doctrine, must be fed with a daily dosage of personal vehicles, channeled over a multiplying number of arteries into all corners of the city.

There are now two city street patterns which transcend all others. They are the pre-automobile and the post-automobile patterns. Cities are of a dual nature. First, there is the older frame of the city, carrying a new breed of traffic--for which it was not designed--with mixed success. Second, there is the newer growth of the city, built specifically for the age of the automobile, found both at the periphery and penetrating the core. The former suffers increasingly from abuse and usage for which it was not intended. The latter has dedicated a large proportion of its area to the function of circulation. It has scant use for the man afoot, who in its province is both vulnerable and impotent.

As men have need for increasing numbers of relationships in their specialized lives, they have sought to fill them by expanding the channels of flow. But it may be that they have effectively negated much of their progress in transportation within their cities. Cities are either strangled by the very innovations designed to improve movement, or else, as in the expanded city, diffusion of parts has magnified the problem, so that the wider separation of parts consumes the advantage gained by increases in speeds. Modern man takes an hour to get to work every morning at forty miles an hour. His grandfather got there in the same time at a tenth that speed, while his ancient ancestor, in his ignorance, accomplished the same thing by staying at home. It is questionable whether the process of movement has kept up with, let alone exceeded, the growth of the requirements for movement. Cities, precisely the places of most interdependence and greatest need for circulation, are where the obstacles to movement are largest.

One of the main reasons that street systems are not always successful or alike is that they are not used for circulation alone. Streets grow or are planned in response to a great many causes, not all of them rational. They can be designed with emphasis on a variety of uses, not all of them consistent with efficient movement. The form that a street pattern takes is a compromise, bearing the imprint of geography, the society, and the age, among other factors. The character can stem from military, commercial, political, esthetic or other

sources. Streets can be employed in multitudinous ways. We therefore should not be surprised if they do not always appear as the optimum circulation means. Street patterns are determined by the values of a society, and also the institutions. The occupations of the people, the form of government, property rights, technology and the amount and distribution of wealth of the population all have an effect on the spatial arrangement of the human habitat. Expediency in the first place, and the passage of time in the long run, have marred men's creations.

The task of this and succeeding generations should include an objective analysis and evaluation of these structures from past--and present--ages, to examine their rationality. We are not of an age in which actions and thoughts are governed by magic or mysticism, or by despotism, or least of all by economic liberalism. Hopefully we are passing out of an age of speculation and into one which gives men the ability to control their mortal destinies, including their physical structures and artificial environments. In this age of science it is our responsibility to criticize and to improve, if possible.

It should be worthwhile to these ends to examine the old and the new city-forms, to trace their beginnings, to analyse their parts, and to study their uses and effects upon the city and upon society. Are the new methods of growth the best, or is a return to some older, more logical form to be preferred? Which of the street patterns is best for each purpose, or does it make any real difference at all how a city emerges? Are streets to be adaptive, or is it rather a matter of their proper usage in their original forms?

CHAPTER TWO

USE, COST AND APPEARANCE

It is appropriate to consider street purposes, economics and esthetics together because they are certainly not divided in reality. No street exists or is used without being seen, and of course they all cost something to build and to use. Nothing is done in, to or about a street that does not involve its use, its cost, or its appearance.

A street can be, and usually is, used for more than one purpose. It does not follow from this that all these functions can be performed by or in the street alone, but it is pertinent to a study of streets to consider all factors that touch upon them, to clarify the roles they play, and to place them in a semblance of order. From this we may look at a particular physical configuration and appraise it fairly on the basis of primary functions, relegating secondary items to the positions they deserve.

It has been stressed that streets are for circulation. This would appear to be the overriding function, but this is a broad statement. A more precise assignment might be the purposeful and directional movement of physical things, such as men and material. When movement is purposeful and directional it proceeds from an origin to a destination by the most efficient route, consistent with the satisfactory functioning

of the other vital parts of the city. This introduces a key factor in the understanding and operation of a city circulation network--the fact that a city has a vast array of people, each pursuing his own ends, thus reducing all circulation processes to a mutually low level. Mechanical power and high speed vehicles usually reach a degree of effectiveness much below their potential when used in large numbers at cross-purposes in a restricted area. It may often occur that the human's own peak performance exceeds the machine's in such situations. The density of traffic has the least slowing effect when that traffic is pedestrian.

Streets are called upon to provide avenues of access for a variety of vehicle types, going to and from an almost infinite number of sets of origins and destinations, all in a safe and efficient manner. But as if this were not sufficient raison d'e tre, they are also quite often used for various other functions, among them:[1]

1. Give access to other routes--such as mass transit highways or sidewalks--which are not themselves the final origins or the beginnings of travel, and are at the same time, not streets in our sense of the word.
2. Allow air to enter the city.
3. Allow light to enter the city.

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1. Compiled in part from suggestions offered by G. W. Breese, Director, Bureau of Urban Research, Princeton University.

4. Store vehicles, as in spaces for parking.
5. Protect and provide a route for utility lines, which are in effect streets for materials, information, and energy that have escaped the physical limitations that still plague the transmission of people and much of the materials.
6. Display structures or contents of structures adjacent to the street.
7. Cover or support other "streets", such as subways and elevateds.

It is impossible to arrange these in a hierarchical order that would be suitable for every circumstance or location. Yet it can readily be seen that most of these functions have little to do with the primary one of purposive movement of goods and people between origins and destinations. It should be profitable, therefore, to make certain a street pattern is not compromised by a design which is a response to a relatively insignificant, unnecessary, or unrelated role. A clear idea of what is important and what is not important in a street system, of what must be there, and what can be located elsewhere, can do much toward a realization of a superior street pattern.

How a city uses its spaces, including its streets, is a matter for the people or those in authority to determine. It would seem, though, that whatever the areal division of space in the city, the permanence,

importance, and cost of the street system would suggest that its original purpose should be permanently retained. This has not very often been followed in the case of the older streets, however, and the not altogether heartening results from this evolutionary process are visible to all. It would seem that a definite decision should be made before a street is built as to what its main purpose and capacity would be, and that that decision should not be proscribed by later demands. For example, if it is decided that the streets of an area are to be used primarily for the convenience of the people of that area in going to and from intracommunity points in the most efficient method possible, within certain limits of safety, economy and beauty, then it would be incorrect to allow that purpose to be degenerated into the business of simply moving large numbers of automobiles (not people) about, with neither safety or economy to the people living there, or to be compromised by parking purposes or by the passage of through traffic with neither origin nor destination within that community.

The land use surrounding or associated with the street pattern is a factor in arriving at the street's purpose.[2] How dense is the area to be, and what types of vehicles can be considered or

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2. For an extensive treatment of the relationship between land use and urban traffic see Robert B. Mitchelland Chester Repan, Urban Traffic, A Function of Land Use (New York: Columbia University Press, 1954).

or will be expected to use the streets? Will--or must--most of the traffic be through traffic, or is intra-community traffic to be considered paramount? What will the temporal travel patterns look like, and what will the orientation of travel be? What type of traffic, what volumes, what times, what directions, and for what purposes travel is being performed are questions which must shape the optimum form and operation of a street system.

It is no doubt a difficult, complex and vague task to grasp and determine what the purposes of streets should be, and the order in which they shall take precedence. But having done this step of the thought-process well, the other tasks of minimizing costs and the retaining of visually and emotionally-satisfying structures and relationships shall be made easier. First of all, the goal must be set, and from this the question of how streets are best arranged to meet this goal must follow. All other considerations pale into insignificance beside this. A street system that does not serve its purpose is better not built at all.

Once having decided what the purposes of a street pattern shall be, we must turn to an examination of the ways of getting these purposes fulfilled. One of the most important considerations in this phase of the process is the cost involved. But this does not mean just finding a system which will fit a budget with the least strain. Total costs--taken over the long run--to the general public and to

the individual users, must be our concern. The cheapest means possible over a long period of time and the most people concerned that falls within criteria already agreed upon is the best system.

The competition for public money comes from all sides. It must be used for schools, for welfare, for law enforcement and for every item that a society deems in its interests. In addition, the private expenditure of funds takes its share of the gross productive efforts of a city. Therefore, the question of getting the minimum necessary facility is obviously quite germane. The economic factors that should be considered in an overall analysis of a street pattern include the following:

1. The original cost of the land. This is an increasingly costly item, as streets tend to be built more and more in areas of highest real estate values in and around metropolitan areas.

2. The cost of construction. Minimizing this item calls for a strict adherance to designs of minimum magnitude. Street construction generally follows a constant cost per unit area relationship, so that the more square yards of street that are built in unnecessary lengths and widths, the more costs will go up proportionally.

3. The maintenance and operation of the streets. Not only the physical structure itself, but the personnel and apparatus to keep the streets functioning at top capacity will vary in cost with

different systems, and certainly with longer, more elaborate patterns the physical maintenance will be higher priced.

4. The loss of the use of land for other purposes. Every square foot of land not devoted to street use can be devoted to space for buildings, parks, etc.

5. The direct cost to individual users of the system. The less energy and time required of users of a street pattern the better it is economically. Fuel costs, mechanical wear, and even human power are expensive, and should be minimized.

Normally not all or perhaps even most of these items of cost can be optimized simultaneously. An engineering and economic study of the project and plan, taking all these factors into consideration will show in general which proposed patterns are worth continued and reasonable consideration and which are obviously violations of economic principles, however. Beyond such knowledge, other influences will make the decision for the exact system. It is conceivable that the limits of financial assets, more than any other factor, will determine the nature of the street system to be built. And it is clear in too many existing patterns that previous builders have not seen the ultimate aggregate costs of their works to the community.

One would hope that streets which are used for their proper purposes, and which are economically conceived, would not be unattractive. But we cannot assume that beautiful design will somehow

automatically emerge when the problem is submitted to functional and financial control only. This is no incidental matter to be taken for granted, or dismissed altogether as a nice, but unimportant, side benefit. Surely beauty is one characteristic which good street design must include. The visual and emotional effects derived from using and viewing the circulation routes of a city are vital among the reasons for cities. It should be clear that builders of cities shall not have done their job well if the street system works like a jewelled chronometer, but looks more like a cuckoo clock. The artist's hand must temper the draftsman's. Visual improvements instituted without impairing the usefulness, or significantly raising the costs, of a street pattern can add much to a city's character. A little thought for beauty, and a few dollars for the efforts of a professional planner are not too much to pay for the difference between dullness and vitality. The concern of those who create cities cannot be wholly justified on purely functional grounds, or be stayed always by financial stinginess. No better testimony to the ill effects of creation without concern for aesthetics can be found than the billboards, jazzy facades and grotesque structures that line the streets and highways of America.[3]

Only the fact that our senses have been numbed by the commonplace ugliness around us spares us the full impact of really awful appearance of so many of man's products.

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3. Cf. Peter Blake, God's Own Junkyard (New York: Holt, Rinehart & Winston, 1964).

To make assertions about beauty, appearances, or visual pleasure as a side issue of another subject is dangerous, particularly when one is not trained in such matters. Instead, it is perhaps wiser and safer to relay on the thoughts and work of others better equipped for these things, in general, and content ourselves with only a few cautious observations. It would appear that the following principles will stand testing in most cases:

1. There should be some variety in streets, in their
   a. widths
   b. lengths
   c. directions
   d. interrelationships.

Such variations, when applied with moderation and in consonance with the aforementioned tenants of purpose and economy, can be of emotional as well as practical value. The practical value of variety in cities is demonstrated by Kevin Lynch in his treatment of the images and their uses created by outstanding features of the cityscape.[4] Variety evokes certain images to people as they move through the city, which aids them in finding their way.

2. An open space, such as a street, should not be "a space to be prettied up in the name of amenity."[5] A street layout cannot be

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4. Kevin Lynch, The Image of the City, (Cambridge, Mass. The Technology Press & Harvard University Press, 1960).
5. Elizabeth Beazely, Design & Detail at the Space Between Buildings, (London, The Architectural Press, 1960) p. 12.

altered in basic appearance by afterthought decorations or affectations. The simplest pattern is usually best.

3. No street pattern is so bad but what the community it contains cannot make up for its failures. The pattern of Georgetown and that of Southeast Washington are practically identical when seen on a map of the city. Yet the differences of the two areas are about as complete as possible. It is what is inside the pattern that counts above all else.

Man-made creations are always compromises between what is wanted on one hand, and what can be realized on the other. A street is no exception. For not only must a street system serve its primary and, hopefully, some secondary purposes, but it should also do its job economically and inoffensively. It must be within the financial means of accomplishment, and should at the same time create an intangible asset to its users and viewers in the form of a visual experience which is inviting, relaxing and rewarding. A street system is ideally, then, an able servant, a financial bargain and a pleasant possession besides.

If civil and traffic engineers could build streets without restrictions of any sort, save that the systems should be as near perfect functionally as possible, they might (though it is not assured) create a pattern which would solve the city's communications problems. Fortunately, or otherwise, such a prospect has never been known to have

come to pass. Money limitations impose severe boundaries on all city planners and transportation engineers. Further, sad experience has shown that the best endowed projects are not necessarily the best productions, either functionally or esthetically.

The conclusion must be that purpose, economy, and beauty must each have a part in, but not monopolize, any critique of the street pattern.

CHAPTER THREE

SPACES AND ROUTES

Streets are large consumers of space. Although cities in the United States occupy only about two per cent of the country's land area, they contain ten per cent of the nation's total road mileage.[1] About twentyeight per cent of the developed land area of an average American city is given over to streets.[2] Only land for single-family dwellings exceeds this percentage as a category of land use. These facts point up the extent of the sacrifices of space now being made for street systems.

Before the advent of cities, space was man's most abundant possession. Space engulfed man and dominated him. Since it was not regarded as a resource, it was not valued. In fact, it probably was considered as somewhat less than worthless, harboring as it did, many real and imaginary enemies. If its value was realized at all, it was still to be taken for granted and not treasured or preserved, anymore than the other phenomena of nature could be. Land appeared to be endless, and there was no reason why it should not be used with abandon.

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1. E. M. Fisher & R. M. Fisher, Urban Real Estate, (New York: Henry Hold & Company, 1954), p. 44.

2. Harland Bartholomew, Land Uses in American Cities, (Cambridge, Mass: Harvard University Press, 1955), p. 121. As measured in a survey of ninety-seven urban areas in 1953.

Now, however, things are different, especially in cities. Men have come to acknowledge the importance of space in their lives. Its limited quantity and its preciousness are realized. The law of supply and demand has increased the value of land space in general, and the metropolitan areas especially. People need and want to live in the city, but at the same time they want space. The suburban pattern of today is not only a reflection of an ability to build spread cities, but also of the real desire to do so. There seems to be an awareness of the ever-shrinking share of available real estate, and of its continuing and growing importance in life.

But while families and individuals may be personally awakening and acting, cities, no matter how provident they would like to be, are not free to indulge themselves in such endeavors. The older cities may appreciate their need for more space if they intend to continue to operate in their present fashion, but it is all too late for appreciation in most cities. The old spaces are inadequate, and new space is unavailable to them except at prohibitive prices.

Land space is a commodity--an asset. It is practically a national resource to many countries of the world. Space can be the difference between life and death for some communities. But what is done with spaces? How can it be used wisely and conserved?

Living space may be thought of as consisting of two types: closed and open. Or, put another way, covered and uncovered. There are a

great many things that we can do just about as well in one of these types as the other, given suitable weather conditions. Thinking, resting, writing, reading are examples. But there are other activities that require a particular kind of space for their accomplishment. Travel is an example. One cannot venture very far without utilizing open space for at least part of the journey. Life in the city is a series of periodic and random shifts between open and closed spaces.

It is estimated that over two-thirds of an average person's life is spent indoors, in closed space.[3] Closed space provides protection from excessive exposure to the elements--cold and heat, wind, rain, and snow, and the rays of the sun. Closed space gives privacy. It provides security of person and property against personal and impersonal malefactors. Closed space can be a wonderful thing to have--a sanctuary--whether it be a cave, a grass shack, or a hundred-story skyscraper. Or it can be undesirable, as from a cell prisoner's point of view. But whatever the purpose or attitude about enclosed space, it is a necessary item of life. Moreover, it is increasingly important to men. As more time is spent inside, more

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3. Based on the following calculations:

Sleep:	8 hours × 7 days/week	=	56
Eat:	$1\frac{1}{2}$ hours × 7 days/week	=	10
Work:	8 hours × 5 days/week	=	40
Other:	2 hours × 7 days/week	=	14
	Total		120 hours/week

$\frac{120}{168}$ = 0.71, or slightly over two-thirds.
(hours total in seven days)

space is being devoted to this sphere of life. Most closed structures of the modern world are growing in size. For example, the average new single-family residence of 1958 had 180 more square feet of floor space than one of 1948--a remarkable change in just one decade in the United States.[4] Office buildings and other structures of the central business districts of cities have "solved" the space problem by providing space in layers, but by doing so have aggravated another space problem--the one in the streets.

Closed space is commonly a private matter, and primarily is designed to meet the requirements of the few people who own or use it. From a functional standpoint, closed space can be of any size, shape, color and arrangement that best meets the approval of the relatively small group that is interested in that space, be it a family, a religious group or a corporation.[5] Enclosed spaces can be disjointed, not needing to be related in a continuum to the other spaces, open and closed, about them. A closed space--even a one-room building--can stand very well alone, differentiated from its surroundings, and independent of its neighboring spaces.

On the other hand, the importance of open space in men's lives cannot be denied. There may be persons who remain in closed spaces all their lives, but they must have access to the outside, through

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4. <u>25th Annual Report</u>, Federal Housing Administration, U. S. Government Printing Office, Washington, 1959.

5. Subject, of course, to the legal standards of safety and appearance established by building codes and zoning ordinances.

others. Mankind must have open space, even if some individuals need not. Open Space provides or makes possible the provision of many of the necessities and amenities of life. It furnishes air and light, and allows freedom of movement, recreation, and communion. All these things are part of a full life. It is now recognized that parks and gardens, playgrounds and walks, and simply distance between buildings are vital to physical and mental health. But open space serves another function which has become increasingly important in modern society: the circulation of men and materials.

Circulation means access--to other people, to things and to other places--without which specialized men cannot live. All types of space are certainly valuable, but none so much as that which is devoted to circulation. The amount of air, or light, or exercise that man of today needs is no greater than that of his counterpart of five centuries or five millenia ago, but the need for transporting people and things has certainly mushroomed. Therefore, the questions of how much circulation space is necessary, and how it shall be arranged, are of growing importance. Space for movement is beginning to be a real restraint on the affairs of men. To fail to provide proper circulation space will affect all the other spaces, but where there is access, there, within each reach, the other spaces will survive.

Circulation space, unlike other open space, and most enclosed space, is generally a public affair, and is of interest to society

at large, instead of to individuals and groups. Even a society so fortunate as to be able to provide, from the private sector of the economy, for most of its space requirements, is still unable economically to build and control private urban circulation routes. The mass usage and consequences of a city's route system places this type of space in a paramount position among all the useful spaces of man.

In considering the activities and movements of men in their daily lives, it may be helpful to think of urban space as being divided into several types, according to use.[6] These might be listed as follows:

A. Closed Space
   1. Still/Slow Space

B. Open Space
   1. Still/Slow Space
   2. Units-in-Motion Space
   3. A Transition Stage
   4. Masses-in-Motion Space.

Still/Slow space is about what its name implies. It would be mostly still space were it not for the movement that is necessary to enter and leave it. No spaces that men occupy remain as just still

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6. Space can be classified in various ways. Christopher Tunnard and Boris Pushkarev, in Man-Made America, (New Haven: Yale University Press, 1963), distinguish open spaces by four functional criteria: Productive, Protective, Ornamental, and Recreational. Stanley B. Tankel says, "I distinguish between the kind of open space of which people are personally aware and the open space of which they may be unaware but which nevertheless affects their daily lives." In his chapter, "The Importance of Open Space in the Urban Pattern," Cities and Space, ed. Lowdon Wingo, Jr., (Baltimore: John Hopkins Press, 1963), p. 58.

space for very long. In addition to the motion of entry and exit, motion without conscious destinations and origins can occur within this type of space also. The rooms of a house and neighborhood playgrounds are examples of still/slow space. Units-in-Motion space is the area in which men and materials are in motion near the extremities of their journeys. They are approaching or leaving the still/slow area in individually guided and powered units, and their movement is purposive. They may be in company with scores of others, but they can maneuver, changing speeds and directions without detriment to other units-in-motion. Autos on residential streets and pedestrians on a downtown sidewalk are examples of this type of motion. In history, units-in-motion space, together with still/open space, constituted practically the sum total of man's useful open space before the Industrial Revolution. Military excursions were the most obvious departure from this norm, until technological advances in transportation brought new dimensions to city travel in general. The transition stage is just what its name implies--spaces where there may be a mixture of unit and mass motion, and where it is difficult to state definitely which kind of use is taking place. Moderate to heavy automobile traffic on central business district streets is probably of this type. Finally, masses-in-motion space is where things, and people in things, are moving at high speeds, over fairly long distances, and in great quantity. They are being swept along, having only limited

control over their speeds and destinations. Today a great deal of space is devoted to this type of use. Freeways, limited access highways, and rail systems are examples of such spaces. It is not at all uncommon for a new urban highway to destroy a continuous stretch of a city a whole block wide, or for a single interchange to spread itself over a score or more acres of land. Table 1 shows the various types of space according to this classification, and provides some amplifying information about each.

It will be noted that this division of spaces makes no distinction between passenger and freight traffic, which are very common categories of transportation. It is undoubtedly useful and necessary to deal with transportation in these categories, but insofar as a study of the routes--the land spaces--they occupy are concerned, it seems that it may be less useful, or less necessary to so separate traffic. The critical features of movement, when determining the proper patterns of routes within the city, are mainly the speeds and masses of the objects moving, and only secondarily and in selected spots of the city, is the cargo being moved a prime determinant.

There are a number of factors which must be considered in evaluating or planning the allocation of space. It is not enough that spaces be visually satisfying, as a medieval street or as the Baroque boulevards were intended to be. Neither organic development nor geometric exactitude can insure the successful outcome of a system

TABLE 1

A TYPOLOGY OF OPEN URBAN SPACES[a]

Space	Example	Activity	Speeds
Still/Slow	Residential yards, paths, playgrounds, parks, walks, narrow and quiet streets	Sitting, walking, playing, bike and horse riding, slow and infrequent autos, parked autos	Under 10 mph
Units-in-Motion	City sidewalks, minor streets with moderate traffic	Entering and leaving still/slow space independent units in purposive motion, bikes, autos, delivery trucks	10-25 mph
Transition Stage	City streets with heavy traffic	Inter-community movement, collecting and distributing individual movers, feeding mass-movement spaces	25-35 mph
Masses-in-Motion	Major arteries, limited-access roads, subways	Metropolitan transitions, rapid motion of large quantities of people and things	Over 35 mph

a. Adapted from information furnished by Charles K. Agle, Instructor, Graduate Community Planning Seminar, School of Architecture, Princeton University

of open spaces that has a function to perform. The right quantity of space for the use to which it is to be put is important, and so is the proportioning of spaces among the several uses. Spaces must be properly meted out and located appropriately. One factor to consider is the amount of time that people spend in each type of space. This can indicate a rough idea of the proper apportionment of space at first, but is obviously not the only consideration. We need also to take account of the amount of room required for the particular activities to be engaged in the spaces involved. In circulatory space, thought must be given to speeds, vehicle sizes, traffic capacities and land use of the related closed spaces. High speed does not necessarily mean great traffic capacity, as is seen in Table 2. One should not become blinded to the real purpose or use of the whole city or community in an attempt to maximize traffic capacity through or into an area, either. Movement in itself is not generally the final goal of the movers. Using the city street system is not regarded by many people as the ultimate in productivity and satisfactory living.

Circulatory spaces should be measured by their efficiency, economy, convenience, comfort, safety and appearance. In other words, an ideal route would serve its intended purpose well, be cheap to maintain and construct, be available upon demand, be reliable, and accident free, and finally, look well. Needless to say, not many street patterns can fill all these requirements.

TABLE 2

CHARACTERISTICS OF TRANSPORTATION MODES[a]

Mode	Speed (mph)	Area required per person (Sq. Ft.)[b]	Route Capacity[c] (Persons/ Hr./Ft. of Width)
Pedestrian	3	10	1500
Automobile (4 pass.)	30	250	600
Bus (30 pass.)	20	30	3000
Subway (1000 pass.)	40	20	4000
Airplane (100 pass.)	600	5×10^6	1200

a. Compiled from information furnished by Charles K. Agle, Instructor, Graduate Community Planning Seminar, School of Architecture, Princeton University, and from Boris Pushkarev, "Scale and Design in a New Environment," Paper presented at Design in America Conference, Princeton University, April 30, 1964.

b. Area includes space occupied by vehicle plus "headway" space required around it, divided by number of passenger per vehicle.

c. Figures are neither maxima or average, but may be typical.

Such intangible qualities are of little use in applying a yardstick to an actual situation. Therefore it appears that some other, more prosaic, principles are in order. A few examples are offered which should serve as aids to the prediction or evaluation of success of a circulation pattern:

1. The total amount of open space for circulation is preferably kept at a minimum, but must always depend on the amount and use of the closed space which it serves. What, and how much, is taking place in the closed spaces is the basic determinant of what the open space should be.

2. Circulation space should be shaped to fit the nature of the traffic it carries. Long, straight streets are suitable for fast vehicle traffic, but shorter, more crooked streets are satisfactory for many parts of the community.

3. Separation of different types of traffic is desirable, and is dependent in the first place upon separation of spaces. The wisdom of traffic separation is widely known by now, but little practiced. The first attempt to separate cars and pedestrians completely was in 1929 in Radburn, New Jersey, where the entire community can be traversed by footpath.[7] The satellite "New Towns" built around London after World War II also separate pedestrian and vehicular traffic, and Brazil's

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7. Wolf Schneider, Babylon is Everywhere, (New York: McGraw-Hill, 1963), p. 358.

new capital city, Brasilia, provides three separate arterial systems: elevated walks, two main routes for autos, and a separate network of streets for trucks.[8] Figure 2 is an example of modern residential community development employing the principle of separation. The most effective way to keep things of differing speeds, masses, and directions apart is to keep their circulation spaces apart. Ways of avoiding multiple-use, or changing-use, of pre-designated spaces include the following:

a. Placing distance, both horizontal and vertical, between spaces. A horizontal space by itself is an uncertain barrier, and requires a rather large amount to be effective, but it can be made aesthetically pleasing. Vertical separation is a certain barrier, but it is expensive and frequently unsightly.[9]

b. Erection of a wall or fence. Not necessarily expensive, but often unbecoming. "Natural" fences of trees and hedges are excellent.

c. Insertion of an enclosed space. A very effective barrier which uses space most efficiently so long as the enclosed space is not adversely affected by the location.

d. Arrangement of circulation spaces in hierarchical order, insuring that no space is next to another which is not adjacent to it in the use-spectrum suggested in Table 1. This is not an ideal solution, but is inexpensive, and often about the only answer.

Juggling, adapting and nursing spaces to make them work for us is a necessary and never-ending battle, as increasing interdependence and

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8. Ibid.

9. Vertical separation need not be complete to be successful when used in combination with horizontal separation. Raising a sidewalk just six inches above street elevation provides a highly effective separation barrier between cars and pedesstrians.

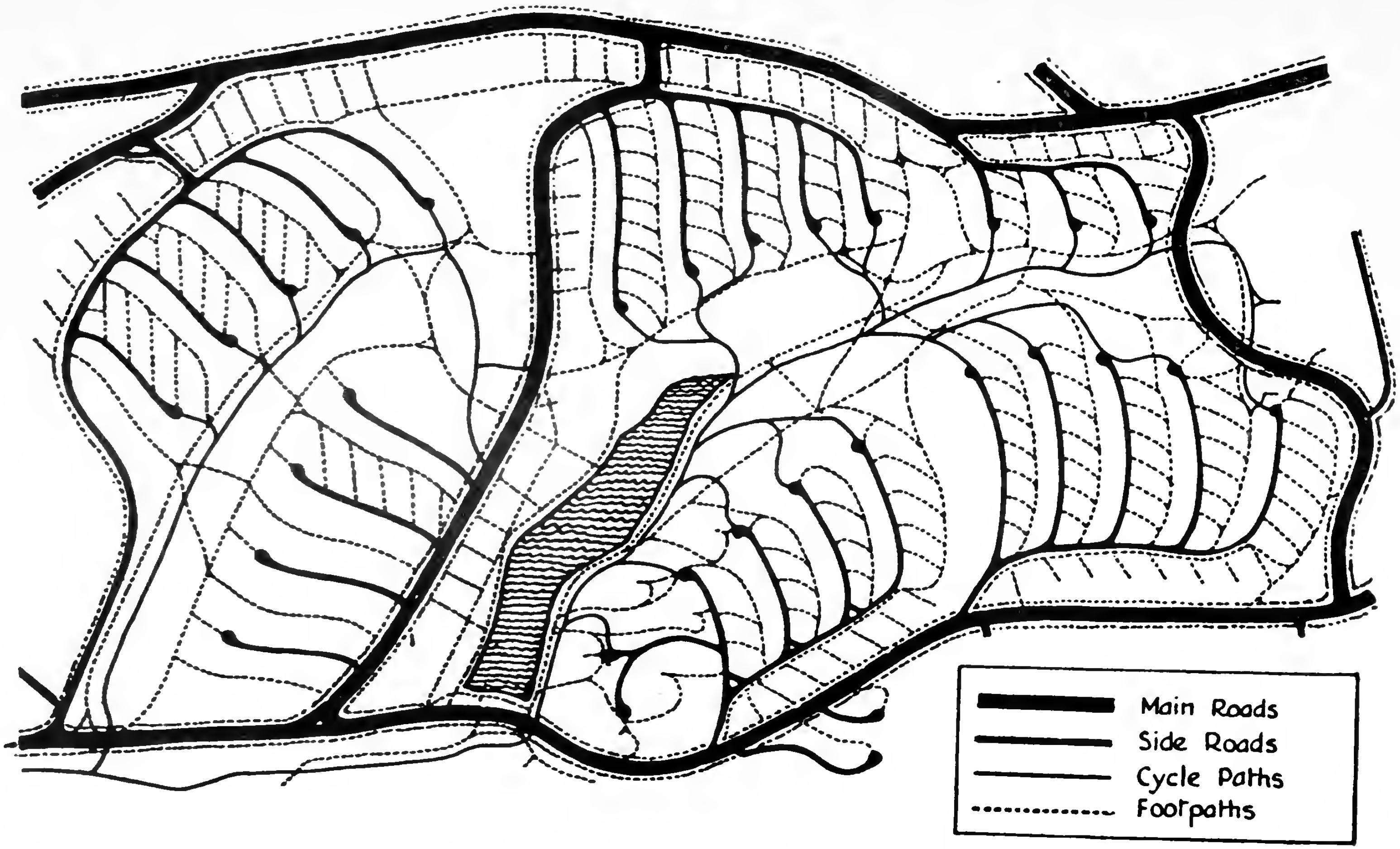

Figure 2.

Separating traffic by separating the spaces that each type of traffic uses, Leverkusen - Steinbuchel (near Cologne). [From Wolf Schneider, Babylon is Everywhere (New York: McGraw-Hill, 1963), p. 359].

affluence constantly create additional demands for transportation facilities. In a way the efforts by planners and traffic engineers are as futile and frustrating as trying to put out brush fires in a dry forest. Every solution seems to stimulate still more traffic in a cyclical manner. But there is only so much space available for life, and surely we do not want to give it all over to transportation purposes. What is the ultimate answer to be?

It would be a mistake to undertake any thought or action regarding city spaces and routes without considering communications in general, for transportation is only a part of communications. Although transportation and communications are now commonly thought of a separate functions, they were originally one and the same thing. While the circulation of men and materials has undergone radical changes, it is true, this is but nothing when compared to the miraculous changes that have been wrought in the transmission of information and energy. First writing, and later electronics, have broken through traditional modes of communications to lead the way in superior methods of transportation. It is to these modes that we should perhaps be turning our attention. Considering the factors of safety, economy, efficiency and convenience, it is obvious that modern communications through electronic means is unmatched by any transportation system. Planners and engineers would do well to ask themselves whether the exchange of non-physical things will not adequately serve the purposes of present

transportation in many cases. It appears basically fallacious, for instance, to move managers, office workers and specialists back and forth in a daily pattern, when they are producing nothing physical at all. Generally their production and their raw material is only information. Why not transport information back and forth to their homes instead? The possibilities of substituting modern communications routes for large, expensive transportation routes appears to be amazingly untapped at present. The transfer of movement from the transportation realm into the communications field may yet bring the proper use of city spaces into better being. As Richard Meier has said, "It is in the area of communications that the greatest changes for our urban dwellers are due to take place, where the greatest social effects can be attributed to technological progress...".[10]

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10. Richard L. Meier, "Planning for Tomorrow's World," pp. 15-23, Planning 1955 (Chicago: American Society of Planning Officials, 1956).

PART II

PATTERNS

The basic physical elements of which streets are made. The factors which influence the locations, character and patterns of cities and streets. The major types of street patterns that are possible.

CHAPTER FOUR

ELEMENTS OF STREETS

If all street patterns were basically alike in their framework it would still be possible and likely that each would be different in many ways. This is because of the fact that the links in this framework--the streets--can be very diverse in their makeup. This variability provides both opportunities and limitations for the street patterns, and so it is necessary to have an awareness of the various and variable elements of streets. The design or analysis of anything, such as a street or a street system, is furthered and enhanced by a knowledge of the separate parts that make up the item under consideration.

What are the factors or elements of which streets are composed? We may begin by noting that factors bearing on the characteristics of streets are either direct or indirect, depending on whether they are part of the street or not. Direct elements are actual physical qualities of the street itself, such as its width or length. If a street system succeeds or fails because of the effects of one of these elements, then we can properly criticize the street for the outcome. On the other hand, an indirect element is a factor that partially determines the quality of a street system, but is not itself part of a street or street system. Indirect elements might include the type and amount

of traffic placed upon a street, or the buildings and other facilities that occupy spaces abutting the street.

There are at least eight separate, direct characteristics of streets. They are: orientation, width, length, grade, curvature, intersections, number and surface. We shall discuss each briefly.

Orientation refers to the general direction that a street takes. It may be in relation to geographic features of the city site, as up or across a peninsula, for example. It may be oriented according to the compass points. Many street patterns contain streets that were originally laid down in north-south or east-west directions, or both. A street may be oriented to serve (or to bar) large population centers or demographic patterns. The more important a route, the more its orientation becomes an important element, and vice versa. Routes which are for local service can abide disorientation, but it should be recognized that orientation is an important asset to a traveler, even one who is familiar with the community and city.

In general, the width of a street need be only the distance required to carry moving vehicles at an appropriate speed. It does not appear that wider streets can be justified on the desire for other, secondary functions, which can more economically and properly be provided by other open spaces.[1] If storage of vehicles, air and light

1. Charles M. Robinson pointed out the folly of making uniformly broad streets throughout the city many years ago in The Width and Arrangement of Streets, (New York: The Engineering News Publishing Company, 1911).

are deemed important to the area, then they should have their own spaces in the overall plan. Often the lack of space between buildings long established, the lack of funds, and other reasons preclude widening of streets, in which case the traffic type or volume should be controlled. Cities have rarely been fortunate enough to have anticipated and planned for their long-range street needs.[2] As a result, a later attempt to either modify the street systems, or to carry all the traffic that wishes to enter a street, creates costly and unsatisfactory conditions. Widths can vary on the same street as the need varies, and for other effects. Visual appeal, parking spaces, turn-around areas, avoidance of obstacles, and traffic separation spaces are some reasons for having various widths of streets besides the main one of traffic nature. See Figure 3 for some typical widths corresponding to given situations.

One of the ways in which streets are different from highways is control over length. Highway length is generally dictated by the distance between two principal centers of attraction, whereas street length need not be. A multiplicity of streets serving an area allows

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2. L'Enfante could not have foreseen the type and amount of traffic that would come to Washington, D. C. when he laid out his generous avenues. They were designed for the impression they would make as much as for circulation. See Lewis Mumford, The City in History, (New York: Harcourt Brace and World, Inc., 1961), p. 403-409.

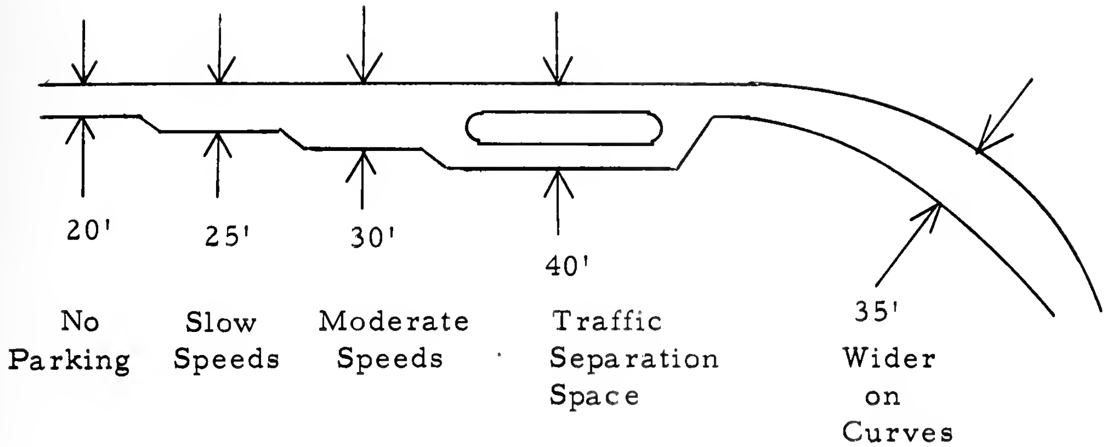

Figure 3

Street widths should vary to suit the conditions.

a great deal of flexibility in any one, since there are alternate routes for most purposes. Streets that are intended for short-distance travel within a community or part of the city can be made short. Where a street will carry long-distance, fast traffic serving important end-points in the city rather than co-equal points of importance all along the route, greater length is in order. A variety of street lengths is desireable. The correct type and amount of traffic will tend to pick the length of street for its best utilization and efficiency. Minor, local streets can be thought of as "stopping" streets, and collectors and arterial streets as "moving" streets, according as the traffic on them intends to stop on them or not.[3] A general

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3. This nomenclature suggested by Charles K. Agle.

rule to follow is that stopping streets should be as short as possible and moving streets should be as long as necessary.

When wheeled vehicles were the exception, a street's grade was not too important. A human or animal can ascend or descend almost verticle slopes if he has to. But when mechanically powered,wheeled vehicles entered the picture, level streets assumed paramount importance. These devices were, for a long period, of high weight-to-horsepower ratios and were unable to negotiate steep grades. Now, however, grades are again being discounted, or at least less noticed, because of the surplus (or reserve) horsepower of automobiles, as well as their gear-shifting ability.[4] This does not mean that grades are unimportant anymore, even if the average motorist is undaunted by them. Climbing and descending still require more fuel, require more time, impose more wear, than level travel. Moreover, steep grades are a danger, especially in conditions of inclement weather, and they present sticky intersection problems. In earlier days there was only one way to avoid steep grades and that was to go around the hill or valley, following the contours of the land closely. Now it is possible, but expensive and not always attractive, to cut and fill rough terrain to reduce excessive grades. Figure 4 shows currently accepted grade standards.

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4. About two per cent of an auto's energy is used to transport passengers, twenty per cent to move the vehicle, and the remainder is either wasted in engine inefficiency or held "in reserve".

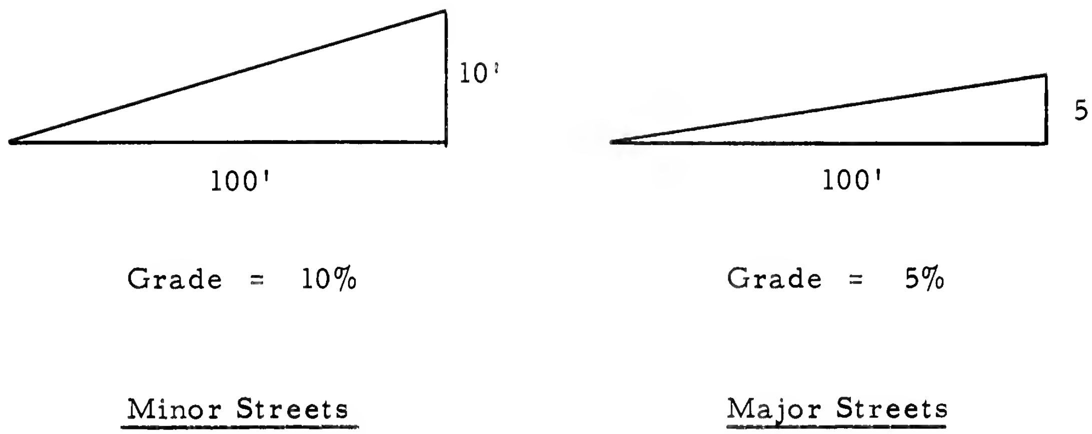

Figure 4

Typical maximum street grades expressed as percentages.

As far as curvature is concerned, a street can be a straight boulevard, a gently curving drive, a wandering, twisting alley, or anything between these. The street may even be a complete circle, as are the circumferential highways traversing some metropolitan areas today.[5] Curvature may be constant, producing a smooth, geometric effect, or varying, yielding an irregular snake-like effect. The radius of a curve may be short, producing a sharp turn, or long, producing an easy curve. A right-angle turn is a special case of the curve, having zero radius of curvature. Curvature introduces

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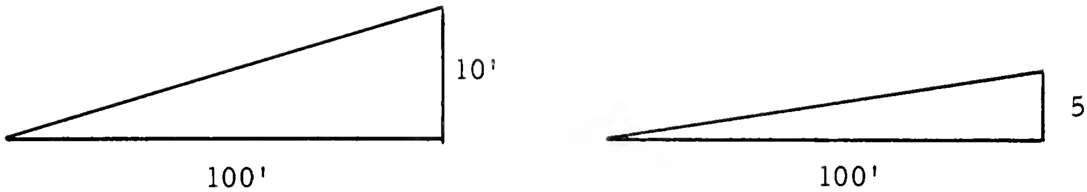
5. Baltimore, Maryland and Washington, D. C. have examples of this type.



Grade = 10%   Grade = 5%

Minor Streets   Major Streets

Figure 4

Typical maximum street grades expressed as percentages.

As far as curvature is concerned, a street can be a straight boulevard, a gently curving drive, a wandering, twisting alley, or anything between these. The street may even be a complete circle, as are the circumferential highways traversing some metropolitan areas today.[5] Curvature may be constant, producing a smooth, geometric effect, or varying, yielding an irregular snake-like effect. The radius of a curve may be short, producing a sharp turn, or long, producing an easy curve. A right-angle turn is a special case of the curve, having zero radius of curvature. Curvature introduces

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5. Baltimore, Maryland and Washington, D. C. have examples of this type.

secondary effects, such as visual variety, and added length of travel. Curvature can be introduced deliberately into streets or removed and avoided as the occasion seems to merit each course of action. Figure 5 shows some examples of curvature in simple forms.

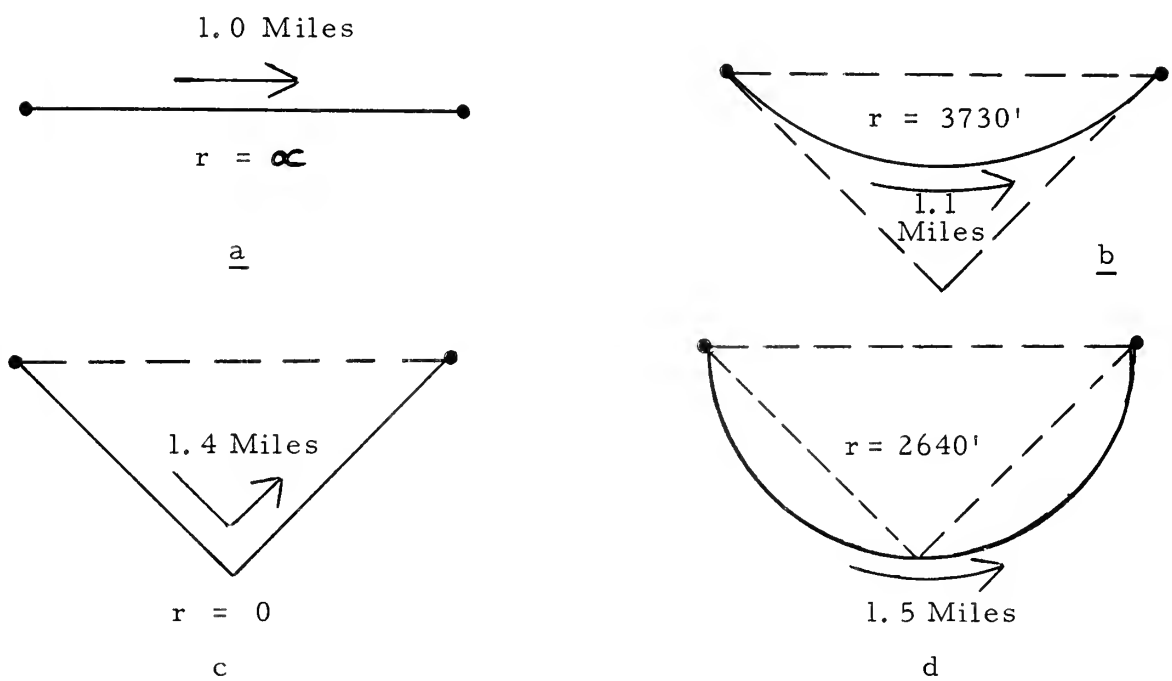

Figure 5

Extreme examples of curvature, showing relative travel distances incurred by each. Figure 5 b illustrates the practicability of introducing curvature to streets with only a ten per cent increase in travel distance.

The feature of a street system that affects as much as anything else, the capacity and ease of traffic flow, is the type and number of intersections. The angle of intersection, the channelization of traffic, the number of routes forming the intersection, and

the signals and other controls that artificially control traffic all affect the character and quality of a street pattern. Intersections are basically arenas for institutionalized conflict, where objects and people with different goals are forced together. Sometimes there is violence, but the normal result is more like a negotiated settlement with some sacrifices on both sides. There is bound to be a net loss of movement at any intersection, and it is the good street pattern that makes its numbers and arrangements of intersections such that this loss is held as low as feasible. Accidents can be reduced by cutting down on the number of intersections also. It has been found that the majority of accidents in urban areas occurs at intersections.[6] Figure 6 shows the conflicts arising from two types of intersections. Figure 7 depicts several basic types of intersections possible.

It was mentioned that streets differ from highways because of their multiplicity. This creates another factor or element of a street system--the number of streets. This element determines, along with the width factor, the percentage of land use which a street system uses. It also has a bearing on the sizes and shapes of the blocks of a city, as well as the enclosed spaces on those blocks.

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6. Committee on the Hygiene of Housing, American Public Health Association, "Planning the Neighborhood", City Planning, ed. Theodore Caplow (Minneapolis: Burgess Publishing Co., 1950), p. 145-156

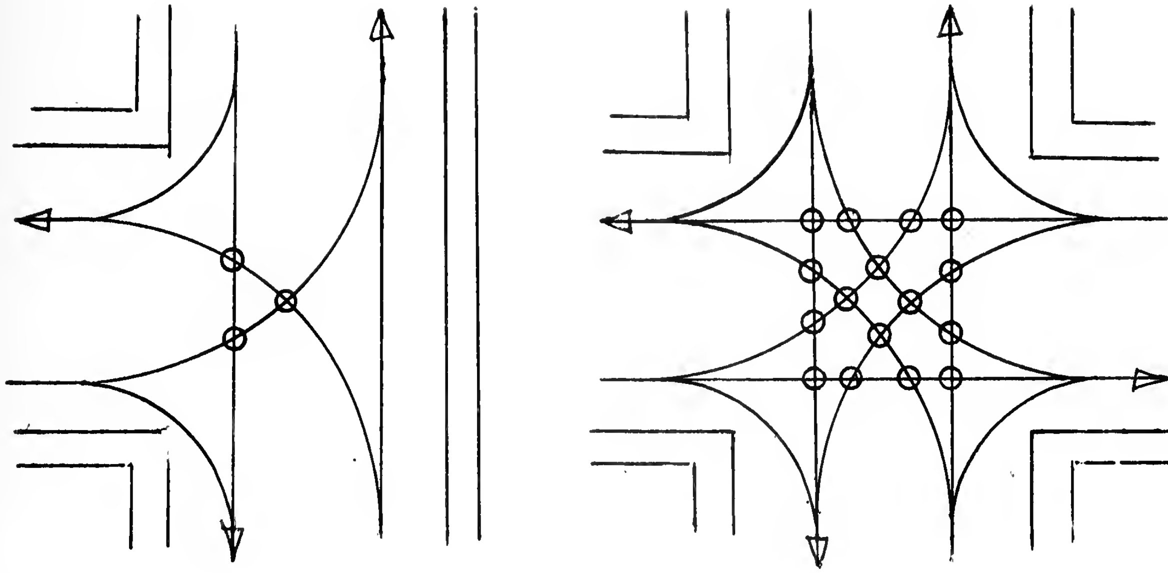

Figure 6

Traffic Conflict Points at Tee and Cross Intersections. [From Urban Land Institute, Community Builders Handbook, (Washington: Urban Land Institute, 1960), p. 209].

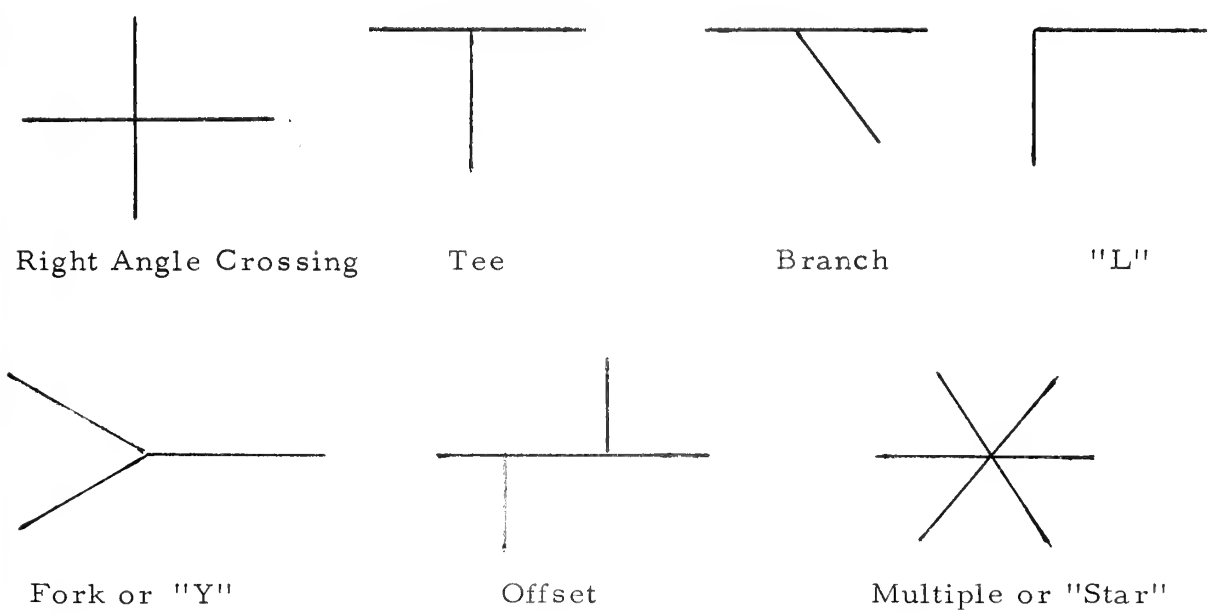

Figure 7

Some basic types of grade level intersections

The number of streets (and their arrangement) determines the availability of choices of routes. Having a wide assortment of routes to choose from is a valuable asset for a street system. It allows a general leveling of traffic volume in a semi-automatic fashion as travelers will naturally try to find the least obstructive route. It also permits repairs to be made to streets with less disturbance to traffic then would be possible if there were only a single route. An accident or traffic jam on one street can be circumvented, also.

The final physical element of streets to be considered is its surface. This is usually pavement in the modern city, but there is no reason that the surfaces of all streets need be so. Paved streets are called "all weather", since the hard surface is impervious to moisture and keeps the sub-grade dry and stable. The pavement also supports heavy loads which would otherwise sink into or erode the nonpaved surface. But where light loads and infrequent traffic is the rule, consideration should be given to simple soil or gravel streets. This will cut the cost of street construction and possibly maintenance, will discourage heavy and fast traffic from using the street, and will allow precipitation to enter the ground to become ground water available for the community's water supply instead of wasted runoff. The cost of a street can be adjusted even among types of paving, too. The type of pavement and its thickness should be varied to meet the loads that will be placed upon the street. Many towns and cities have only

one set of specifications for their streets and this is applied indiscriminately all over the community. As with the other physical features of streets, the rule should be to make the street fit the need and no more or less. The surface of a street may also be shaped in cross-section in different ways to accomplish generally two functions--to shed water by use of a crown, and to assist curvelinear motion of vehicles by use of superelevation on curves.

These elements constitute the major direct, physical characteristics of streets. The other type of affecting factor is the indirect group. This includes: The use of the street, especially the noncirculatory uses, the adjoining land use, and the facade--all the things between the street and the interior walls of the abutting buildings. The typical motorist or citizen can find a world of difference between two streets that in themselves may be exactly alike simply because of these indirect street parts-by-association.

Parking on-street is the factor that most often is mentioned as the villain of our streets, and it is of course obvious that this is a very serious user of space that might otherwise go for circulation purposes, or might result in narrower streets where there is no need for larger traffic capacities. Bureau of Public Roads research has revealed several other types of street usage that have great effect upon the character and capacity of the street.[7] These are:

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7. U.S. Department of Commerce, Bureau of Public Roads, Highway Capacity Manual, (Washington: U.S. Government Printing Office, 1950), pp. 81-87.

1. Bus Stops--Reduce effective street width by 8 to 20%.*

2. Turning Movements--Reduce lane capacity by up to 50%.

3. Traffic Signals--Signs and Lights reduce capacity by an unspecified amount.

4. One-Way Operation--Increases capacity by 100%.

* This statistic should not lead one to lose sight of the ultimate goal of streets, which is to move people, and not automobiles. See Table 3 , page 55 .

The second general type of indirect element of the street system is the adjoining land use. This is the factor that generates both quantity and type of traffic in an area. Except for pure recreational driving and walking, all motion has a destination which is determined by the attractions unique to a certain spot of geography. The activity that transpires within the areas that the streets serve is what really counts. This factor should be the starting point in any consideration of traffic and routes. This is the factor that causes peaks and lulls in street usage. It creates a demand that can hardly be quenched by attacking the end product--the street and its traffic. The vehicles that use an industrial area will be quite different from those in the central business district of a city, or from a quiet residential suburb. The density of people living or working in an area, the wealth of that area, the activity going on in the spaces between the streets--all bear upon the street and help to make it what it is.

Lastly, the facade. This includes more than just the faces of the structures along the street. It is the sidewalk, the lighting, the trees (or the absence thereof), the proximity of structures to the street, the spacing of the buildings, their height, and the state of cleanliness and repair of the area. The facade, much more than the street itself, creates the esthetic value of the street. More than this, from a strictly functional standpoint, facade affects circulation. For example, it has been found that the closeness of physical features to a street will reduce the traffic capacity by a significant amount. See Table 3.

TABLE 3

EFFECT OF EDGE CLEARANCES ON CAPACITY[a]

Distance From Pavement Edge to Obstructions, Ft., (both sides)	Street Capacity as a Percentage of Maximum Capacity
6	100
4	94
2	85
0	76

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a. From Laurence I. Hewes and Clarkson H. Oglesby, Highway Engineering, (New York: John Wiley and Sons, Inc., 1954), p. 151.

It is seen from this discussion of street and nonstreet elements that we are dealing with a multiform subject. The character and usefulness of a city and its streets are dependent in large measure upon the quantities and qualities that these diverse elements take on. These are the basic variables upon which patterns are dependent and by which the city can be enhanced or victimized. A pattern is not nearly so simple as a series of lines in plan drawn to small scale. The real pattern may not be visible at all except to those who experience it daily on the ground. The view in perspective is necessary--but not sufficient.

CHAPTER FIVE

INFLUENCING FACTORS

Students of the city are familiar with the many reasons and theories that have been put forth to explain the existence, locations, and the growth patterns of cities. At risk of being superfluous, some of these will be briefly reviewed here, in order to prepare the way for a discussion of the factors that have influenced the street patterns of cities. There is, of course, a relation between each of these phenomena, though there is also an independence about each. The street arrangement appears to be particularly independent. Knowing why a city exists will tell one something about why it is located where it is. Knowing its justification and situation gives a clue as to its reasons for growth in certain directions. But as often as not, a knowledge of all these things will not explain why the streets are laid out the way they are. We must seek an answer to this question from among another set of criteria and influencing factors.

Though each city has its own specific and unique reason for being, they can all be generalized into a fairly short list. The basic factors that permitted the growth of urbanism over the past five or six thousand years are summarized in many books dealing with urban

sociology, urban history, and urban geography.[1] E.A. Gutkind has probably covered just about all the reasons for mankind's trend toward city life in the following listing:[2]

1. The general, and most basic reason--Man is gregarious.

2. The specific reasons--

    a. Protection against nature and men (The Oasis Town and the Fortified Place)

    b. Worship (Temple and Cathedral Cities)

    c. Kingship (Castle and Royal Residence Towns)

    d. Politics (Administrative Cities)

    e. Industry (Industrial Cities and Craftsmen's Towns)

    f. Trade (Trading and Road Cities)

    g. Expansion (Colonial Towns, Satellite, New Towns)

    h. Reforms (Improvement of Living Conditions, Housing)

These city reasons and types are in rough chronological order of their first appearance on earth. Though few cities could be considered

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1. Cf. Lewis Mumford, The City in History, (New York: Harcourt Brace and Co., 1961); Noel P. Gist and L.A. Halbert, Urban Society, (New York: Thomas Y. Crowell Co., 1956); Griffith Taylor, Urban Geography, (London: Methuen and Co. Ltd., 1951).
2. E.A. Gutkind, The Expanding Envirnonment, (London: The Freedom Press, 1953), p. 27.

exclusively of one type, most do have one characteristic which predominates. Two types are not included in the list, but are of growing relevance to modern society and are deserving of inclusion. They are the Educational and Resort Cities. The increase of leisure time and wealth will undoubtedly result in more Princetons, Ann Arbors, Miamis and Las Vegases.

Knowledge of the proper conditions and reasons for cities leads to the next question. Where do cities locate? What are the environmental conditions conducive to the existence and growth of cities? The one factor that may be the most significant influence upon location is chance. This is so obvious that it is often forgotten, but it cannot be denied. We must remember that when most cities now existing were formed, the earth was a vastly larger place for men to get around in. Men could not know, much less get to, most of the face of the earth, and so cities formed where men happened to wander, to land in their exploring vessels, to be driven by nature or other men. To search for reasons for a city on this bank of the river instead of that one, or in this valley in place of that richer one, or at this place on the road and not one a little further on, is frivolous. To say that chance is a locating force can possibly answer some riddles.

On the other hand, accurate though it may be, a predominantly chance theory is not by itself a very satisfying explanation. There are certain quite evident conditions that are favorable to the establishment of human settlements, among them being:

1. A Temperate Climate--This involves both temperature and precipitation. Reference to any atlas will show a remarkable correlation between maps of world population and maps of rainfall and moderate temperature.[3] Griffith Taylor has shown very convincingly how climate affects the incidence of towns and cities in the United States by placing all the states of the Union on a graph, plotting temperature on the ordinate and inches of precipitation on the abscissa. He then shows that cities tend to cluster in states having a mean temperature of around 50^{o} F., and an annual rainfall of between thirty-three and forty-three inches.[4] The results are shown in Figure 8.

2. Moderate Topography--Though cities can be and have been built on rough or swampy terrain, they are generally located on a fairly level, well-drained site. Ignoring geographic or topographic handicaps is not always possible when other factors override the problem of poor terrain. The very lives of the fugitive builders of Machu Picchu, in Peru, were at stake when they chose their soaring, rugged site as were the Venetians in their "water-borne" refuge. So, in a sense, were the lives of the fishermen who established the improbable city of Amsterdam. But, the fact that such cities evoke our amazement attests to their rarity.

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3. See, for example, The American Oxford Atlas, (New York: Oxford University Press, 1951), Distribution Maps I-VII.

4. Griffith Taylor, op. cit., p. 374-376.

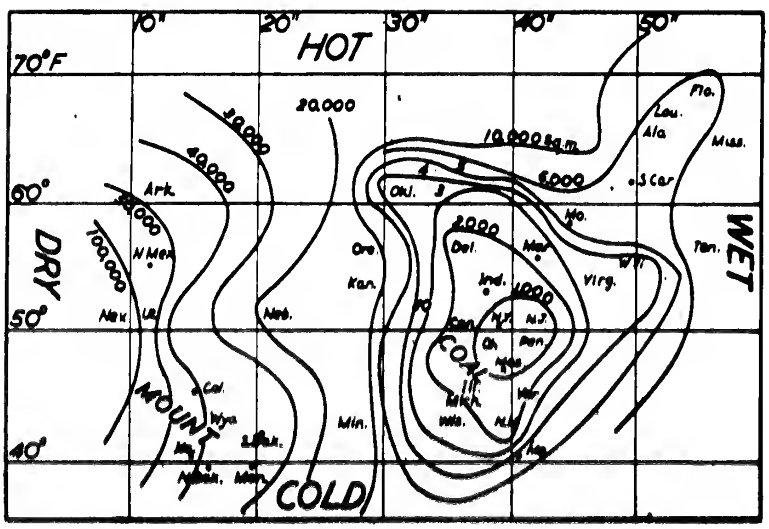
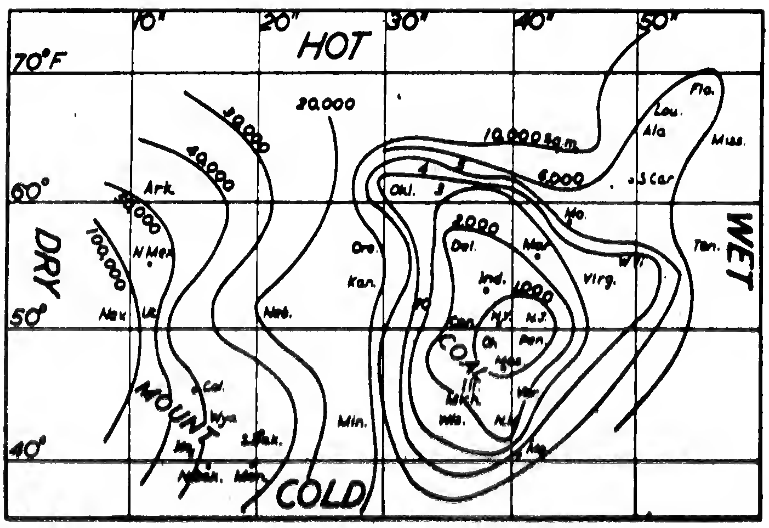


Figure 8.

An "isopract" graph showing how the distribution of towns (exceeding 17,000) varies with climate in the United States. Figures represent the average number of square miles alloted to each town or city per state. California, because of its various climatic conditions is omitted. Alaska and Hawaii were not states when the graph was made. [From Griffith Taylor, Urban Geography, (London: Methuen and Co. Ltd., 1951), p. 375.]



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3. Natural Resources--This may include an agriculturally rich hinterland, or recoverable mineral deposits, or a source of energy, as at a waterfall. A score or more U.S. cities arose on the fall line between the Atlantic coastal plain and the piedmont. Among them were, Trenton, Philadelphia, Washington, Richmond, Raleigh, Columbia, Augusta, Macon, and Columbus, Georgia. In short, any asset which can materially support the city.

4. Important Communications Routes--The travelers' need to rest, to replenish, to exchange cargo carriers, creates a need for a community. Many towns of southern Europe owe their existence to the extensive travel generated by the Crusades. The crossing of two or more routes makes the appearance of a town or city very likely.

5. Defensible Positions--This was one of the earliest reasons for the selection of sites for settlement, but modern warfare has lessened its importance. Still, many of our present cities were initially placed to take advantage of a strategically situated piece of ground.

6. Surface Water--Though water might have been implicit in the mentioning of natural resources, or as one form of a communications route, or even as part of a defensive network, it is so singularly important to city location as to warrant special mention. Water is a many-fold asset to men. It is used for human and industrial consumption It diffuses the wastes generated wherever men live. It is a good medium, or route, for transportation. It may be a source of food. It is often a

place of recreation. It can generate power. Water even acts as an air-conditioner, tempering both hot and cold weather in its vicinity by its relatively constant and slow-to-change temperature. Indeed, it is very rare that a city has grown to large size that was not on or reasonably near a large body of surface water.

Once there is sufficient reason and a condition for a city, and it is established on a site determined by chance or choice, there begin to operate on that city, certain forces that shape and color it, pulling its growth at different rates and in different directions. The pull of other cities, the geographic channels, the transportation lines, the hinterland attractions and the political boundaries of the state and other institutions are at work, forcing the city to flow this way and that. These are extremely complex and intermingled in their action. In fact, their net effects have been observed to produce rather generalized growth patterns applicable to all cities. There have been three general theories of urban growth that have gained recognition for their validity. These are the concentric zone theory, by E. W. Burgess, the sector theory, by A. M. Weimer and Homer Hoyt, and the multiple nuclei theory by C. D. Harris and E. L. Ullman. Figure 9 depicts these theories diagramatically as well as a possible combination of the three.

It is commonly thought that one or more of these theories will fit almost any urban area or city, if proper allowance is made for

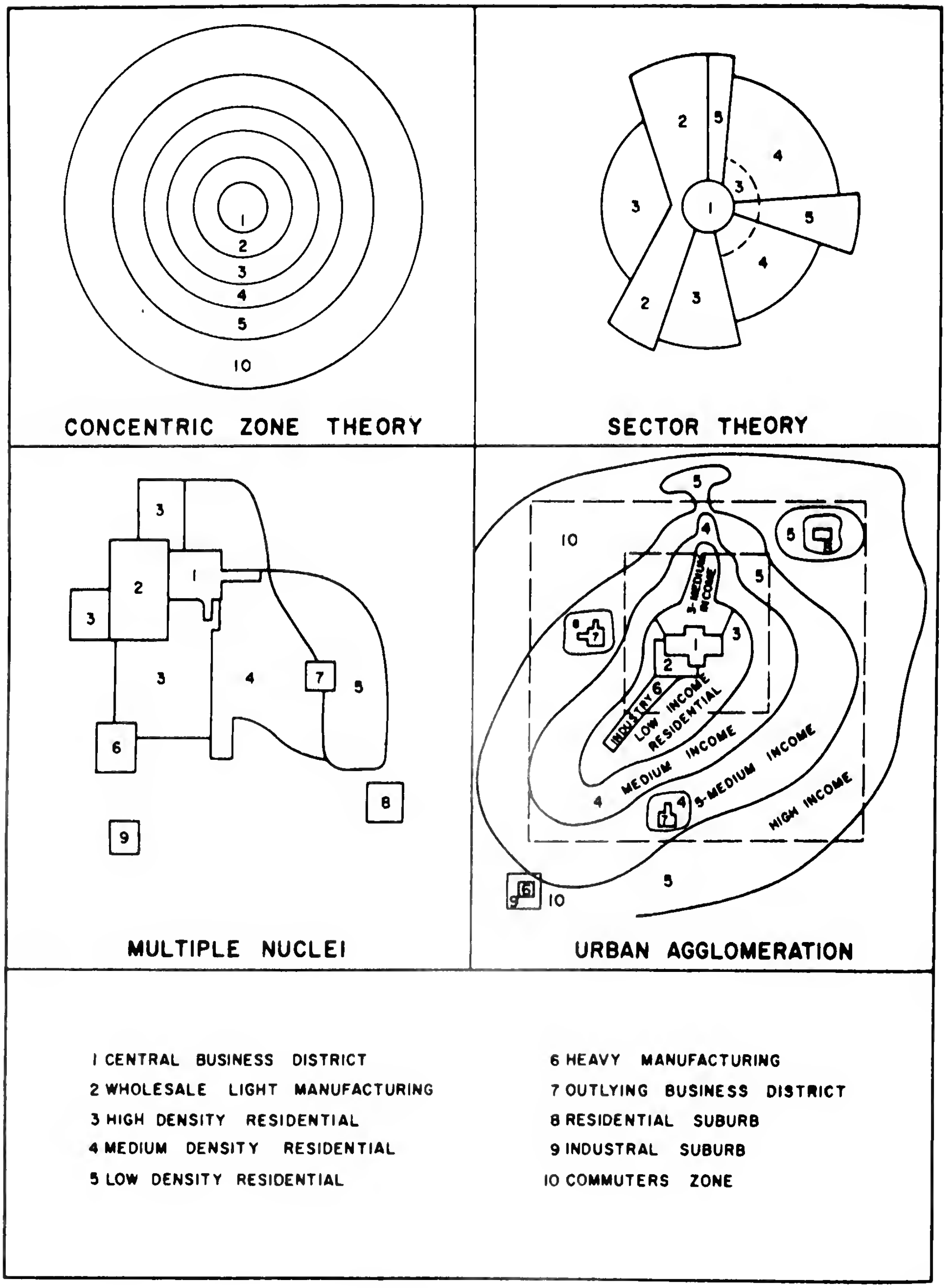

Figure 9.

Diagramatic representations of the major theories of city growth patterns, including a possible combination of the three as an "urban agglomeration." [From Wilbur Smith and Associates, Future Highways and Urban Growth (New Haven: The Automobile Manufacturers Association, 1961), p. 42.]

features that are "unique" to the particular city under consideration. However, even if the theories worked to the perfect satisfaction of all skeptics, they would still be insufficient explanation for the locations and arrangement of the streets of the cities to which they applied. A great deal can be known about cities by understanding these factors underlying the existence, location and growth patterns of cities, but this knowledge falls short when the physical internal patterns are examined for their causes. As has been mentioned previously, perhaps there should be a rational relationship between land use, the function of the city or community, and the streets that serve the uses and functions. But if such a tie exists, no grand theory has ferreted it out, apparently. Cities locate for reason and for chance. Their outlines and internal sociological and economic borders are traced by geographic and other reasons . But is the internal pattern unpredictable? Highways could be said to follow the lines of least resistance to their destination, but what is the street's destination? Given all these causes for the existence, location, and growth patterns of cities, we still have not accounted for the patterns of streets, or at least only partly so.

In a consideration of street patterns two factors stand out that should be kept in mind in trying to understand them--the point of reference and the point in time. The first refers to the fact that though street plans are commonly thought of, and more lately con-

ceived of, as if from a high point overhead, encompassing the whole fabric of the pattern, in reality and everyday use, street patterns are on the ground. A pattern may be eminently satisfactory as a pretty plan and yet not be entirely satisfactory in use and appearance to people in and around it.

The second fact is that, with the exception of isolated modern communities, street patterns as they are seen at one instance are not at all the way they started out to be. We have spoken of the fixity of the street pattern, but it is like a growing crystal. Though it is rigid, yet its size and shape is constantly changing,adding tissue or cells to its structures. The dimensions available on our maps and with our models cannot adequately include the fourth dimension of time in their makeup.

These two facts may help to explain the apparent random and sometimes disjointed street patterns given by a static plan view of the city. A street pattern that is inexplicable from the air in the twentieth century may well have been quite logical and functional on the ground in the eighteenth.

Here are some causes of distinctive street patterns:

1. Topography--Grades are a limiting factor. In days of foot traffic people could go up and down steep slopes, making sudden turns. Then vehicles came along. Animal vehicles needed straighter streets, but could still go up and down fairly steep inclines with

moderate loads. But the mechanically powered, high weight-to-horsepower vehicles called for flat, straight avenues. Now the trend is reversing. Although curvature must be slighter than ever, the grades, while not abrupt from one to another, can still be very great without being prohibitive to traffic. Topography is less important now because we can (a) change it, or (b) overcome it. Nevertheless, the most modern streets will consider topography because of the expense to the user that results from not observing it. Rough topography will produce a more shattered, random, curving pattern than will a flat, featureless plain. Violations of this rule are regretfully legion.

2. The Environment, or Nature--A pattern may have arisen to make use of or to nullify the effects of a natural phenomenon. Some early city planners spoke of orienting the streets to block the winds; others would seem to want to catch the breeze to drive out foul odors. Arid regions would seem to lean toward narrow and few streets because of the torrid sun on any outside spaces and to reduce the production of dust on the wind-swept streets. Houses oriented to the southerly exposure will result in a street system running East-West.

3. The presence of a body of water--Major streets tend to parallel the shore of a lake, ocean or river. Building up on this street requires another behind it, and a few connecting streets to allow openings to the water appear. This produces a spinal, one-sided effect.

Canals dug out from the water into the hinterland may appear and give rise to another pattern at right angles to the first. A rough grid pattern emerges.

4. Custom--The habit of building a city in one form is a strong incentive to continue their construction in that one way. The fact that there are actually so few basic patterns, and that some attain such popularity, may be due in large part to simple custom. Custom was institutionalized in the Law of the Indies, which was a blueprint for the standard layout of colonial cities. A city that works well enough when planned and built a certain way will gain acceptance and will become a model.

5. Irrationality, Status and Psychology--These factors include most of the nonscientific causes. For example: the orientation of streets in a certain direction to appease the gods, the over-emphasis of width to inflate the ruler's and the people's egos or the rigid geometry as an assertion over nature.

6. Man-made obstacles--Railroads, freeways, industrial areas, cantonments, walls and canals all force streets to terminate, to circumvent or to parallel the obstacles. These structures warp and stretch communications lines and sometimes serve as breaking points separating one type of pattern from another. The city of Rangoon shows the effects of the cantonment, the river and the rail line as restrictors of circulation. See Figure 10.

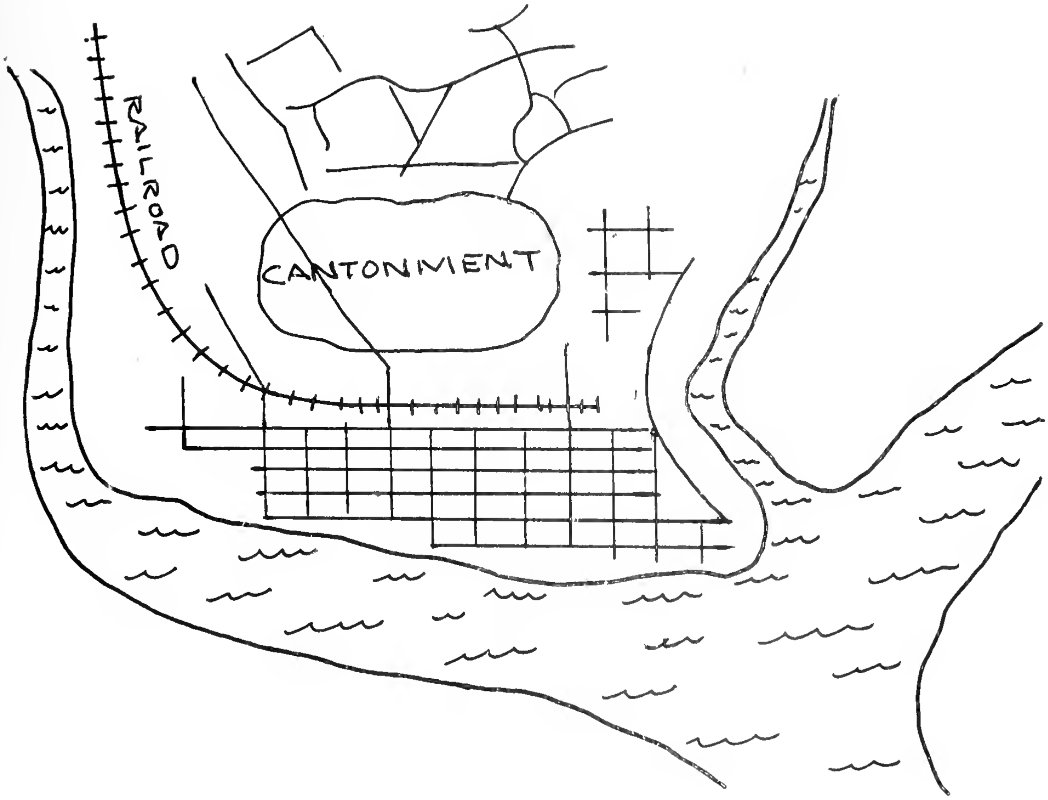

Figure 10.

Sketch of Rangoon showing barriers to street pattern continuity.

7. Military reasons--A street needs to be straight and wide for marching troops and for the training of cannon fire. On the other hand street systems that are crooked, narrow and unsystematic are excellent for defensive action. The benefit of either type of pattern all depends on the origins of the threat to the security--whether from outside or from within.

8. Modernity--A combination of recent ideas, values, and inventions that have given birth to street patterns not possible two centuries ago. Ideas: Variety on a planned basis, for amenity, traffic control through the way a street system is laid out, patterns for the

automobile primarily instead of as an interloper, the use of a minimum amount of space dedicated to streets (but with autos instead of people, this idea is more than cancelled out instead). Technological developments: Surveying, which allows "perfect" geometric layouts of streets, Engineering which can cut and fill to remake topography, and can cross over obstacles or go under them, and can produce fast vehicles to call for a new form of the city and the street pattern. The third (vertical) dimension is possible and the fourth (time) is overcome by massive all-at-once planning and erection of communities. A few decades ago this was exceptional, except for the Garden City and New Towns ideas. Engineering that can, if politically and socially acceptable, remake a city that is altogether different, as Haussmann did in Paris.

9. The building sizes and shapes--Where buildings are very cheap and temporary, streets are just open space. Where buildings are permanent and costly, and party walls are common, streets are also permanent and paved, and are few and narrow. Rectangular buildings have led to rectangular street patterns which have persisted even after buildings need not be rectangular and are set back from the street.

These reasons should provide some basis for understanding the patterns that have evolved in various cities, but they will certainly not furnish easy or complete answers. Chance and change have managed

so far to limit human efforts toward any total discovery of the fundamental forces behind human creations. It is not a failure to have an outline in lieu of a portrait, and perhaps these underlying causes can help form such an outline.

CHAPTER SIX

IRREGULAR PATTERNS

Whenever several or many streets are viewed or considered together, we speak of the arrangement that they form as a pattern. A great many street patterns appear to have no discernable method to them. They are without ordered repetition in their make-up. They are irregular. This does not mean that there may not be precise similarity of a few parts, or a rough similarity through the entire pattern, but that the general pattern shows an absence of being deliberately regular and repetitious.

Irregular street patterns under consideration here fall into four ages. They are the primitive, ancient, Medieval and modern. Primitive streets can only be discussed in terms that apply to modern-day pre-literate societies, since those of the Neolithic period have left little or no trace. The physical size of these communities and the populations were relatively small, so that circulation demands were minimal. Open spaces predominate in primitive settlements, which is the opposite of the case in all other types of cities. Instead of street space being from fifteen to forty per cent of the developed land, the primitive village had seventy-five per cent or higher open space. Further, the street spaces were temporary, as the buildings, and indeed as the whole "city" may have been. It is clear that though the open

spaces of these communities may have been their streets, they were very different physically and functionally from other streets. Figure 11 is an example of a primitive village plan. The primitive community of today found in remote parts of the world supports the contention that the pre-historic village--the precursor of the city--was of an irregular pattern.

We are on firmer ground, and can state definitely that most parts of the ancient cities' street patterns were irregular. Though it has been found that there were attempts at geometric layouts in the cities of the East between 4500-500 B. C., these were generally confined to the main paths of the city. The principal streets often reflected the need for communications between certain focal points of the city--running from the gates in the surrounding walls to the temple or the agora. The cities of the second and third millenia B. C. in Mesopotamia and in the Indus Valley had what seem to be fairly straight streets throughout, but the design of the overall parts--or quarters--of these old cities is anything but regular. The straightness may have been the result of the formation of straight-sided buildings of clay masonry, with the left-over spaces becoming the streets, which were necessarily also straight. The minor street lengths tended to be very short, producing a rather shattered appearance in plan. The ancient Minoan city of Gournia, shown in Figure 12, is a good example of this age of irregular street patterns.

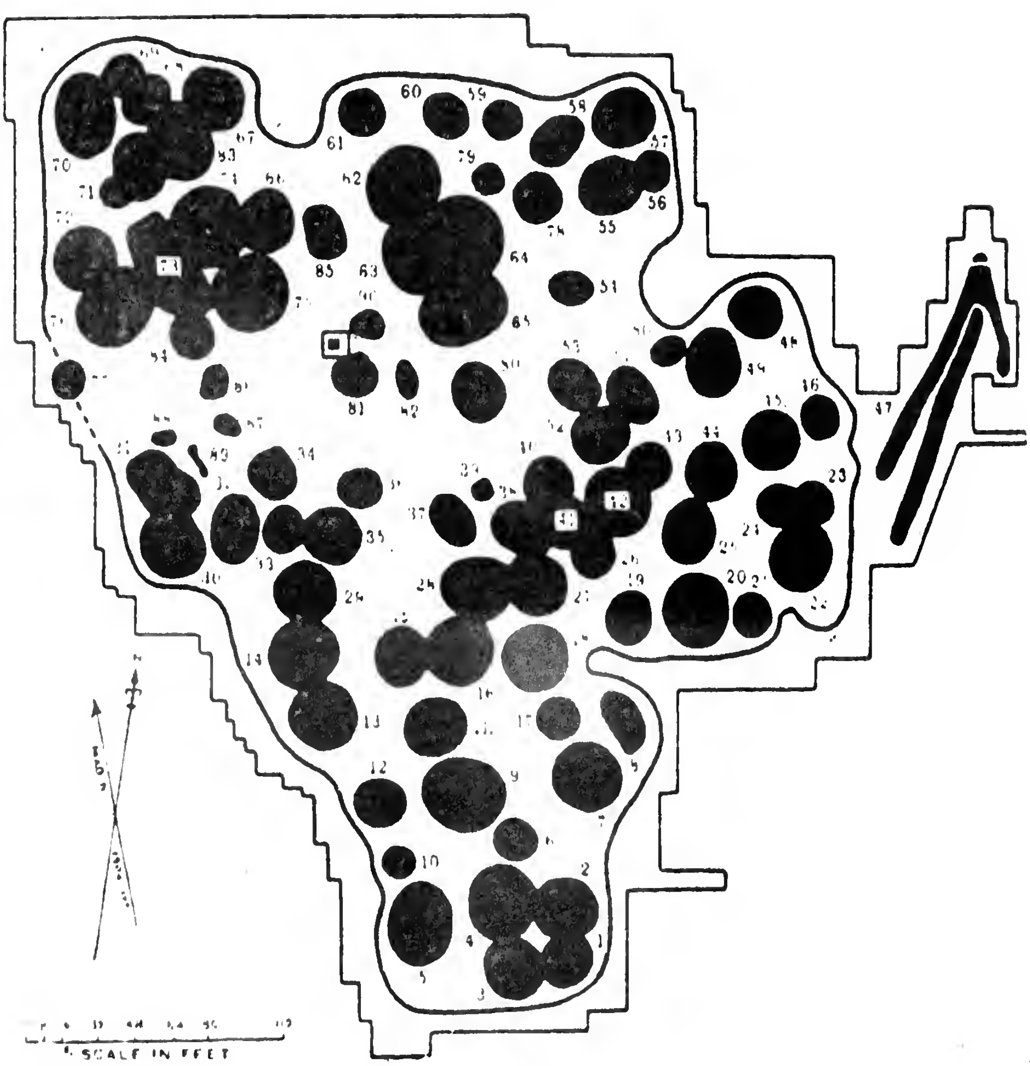

Figure 11.

Glastonbury, in southwest England. A prehistoric settlement with irregularly shaped circulation spaces. This community was built on an artificial island in the middle of a lake. [From L. Hilberseimer, The Nature of Cities (Chicago: Paul Theobold & Co., 1955), p. 131.]

Figure 12.

Gournia, in what is now Crete. This ancient city, with its irregular street pattern, was built about 2000 B. C. [From Frederick R. Hiorns, Town-Building in History (London: George G. Harrap & Co., Ltd., 1956), p. 24.]

The next period and locale known for the irregularity of its street systems was the Medieval period in Europe. The curving street of varying width was characteristic of towns and cities of the middle ages. Many of these are still standing today, much as they were then, providing a rich source for description and surmise:

> "The Medieval street has intriguing characteristics for modern people. It tends to be narrow and winding, with an air of mystery and adventure. One does not see very far ahead, and the promise of fulfillment is always one step beyond.[1]

Medieval towns were built on poor sites for regular patterns because of the need to select an easily-defended position, on a crag for instance. The town adapted itself to the site, with streets following contours, streams, cutting around big trees or rocks that have since disappeared. There were walls for defense, and as in the ancient walled city, the main streets led from the gates, finding their way eventually to the nucleus of the town--a cathedral, perhaps. Streets were not the predetermining lines upon which houses were built. Groups of occupations or similar structures would cluster and the streets would be the footpaths which marked the internal and external comings and goings in the town.[2] Whereas it is no easy task to trace out the minor circulation routes in many plans of ancient cities, this is not true of the

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1. L. Halprin, Cities (New York: Reinhold Publishing Corp., 1963), p. 17.

2. Lewis Mumford, The Culture of Cities (New York: Harcourt Brace & Co., 1938), pp. 53-56.

Medieval town. Circulation had achieved a more prominent place in urban life, and even the smaller routes stand out in the plans. The Town of Bruges, Belgium (Fig. 13.), founded in 865 A.D. on a North Sea inlet, is typical of Medieval towns.

Finally, in our own age, a fourth type of irregular pattern exists, but with an important difference. The modern irregular system is pre-platted and deliberate. The absence of ordered repetition in the suburban developments, "New Towns" and garden cities of the twentieth century is not the after-effect of other human endeavors, but is an object in itself. Planning of street layouts has been going on for a long time, but heretofore planning had been equated with rigid form. It is no longer possible now to equate planning and geometric street patterns. One unique factor in the modern irregular street patterns is that their development often coincides with the development of the land use around them. Early irregular patterns resulted from--and followed the effects--of other city structure being erected. Regular, or geometric, patterns usually preceded the building construction in an area. But here, in the late irregular system, the total community rises simultaneously. There should be little excuse for error or inferior street patterns under these conditions. The opportunity to match the circulation function to the needs of the area is unexcelled. See Fig. 14 for a typical modern irregular street pattern.

Figure 13.

Bruges, Belgium. An example of the street patterns of cities in Europe during the Medieval period. [From R. S. Wurman, et al., The City, Form and Intent (Raleigh, N. C. · Student Publication of School of Design, 1963.)]

Figure 14.

Radburn, New Jersey. An American "New Town," embodying the modern irregular street plan. [From Richard B. Andrews, Urban Growth and Development (New York: Simmons-Boardman, 1962), p. 380.]

What are the specific characteristics by which a street pattern may be termed irregular ? There are several, none of which by itself could stamp a street arrangement as irregular, but which, in various combinations, can compose a plan which defines description by geometric terminology. These would include:

1. Curved or crooked streets--Degrees of curvature may vary widely over short distances and from street to street. Straight stretches are relatively short.

2. Varying widths of streets--There was no standard width of street in Medieval and ancient irregular patterns, and one street might open and close its boundaries frequently and abruptly. Present irregular patterns adhere to standards which set forth the general widths of each type of street, but there is room for variety among the functional types.

3. Varying lengths of streets--Streets may be a few hundred feet long, or several miles long. An area is not served by streets that all transit it completely.

4. Random orientation of streets--Directions are not determined by points of the compass, or the relationships to other streets on a strict angular basis. This results in variable distances between adjacent streets.

5. Non-repetitive relationships--This is really the only necessary condition for a pattern to appear irregular, and it stems from the existence of the first four conditions.

It is not hard to find the causes for the irregularity of streets pf primitive, ancient and Medieval cities. Briefly, the people of these cities lacked both the will and the need for regular, orderly street systems. Psychologically and technically, their cultures were basically "natural", and their artifacts reflected nature's casual ways. We can list a few of the most important specific reasons for their irregular patterns. Most important of all perhaps, was that man was still the subject of nature. He was not the master or manipulator of the earth yet. He had respect for the cosmos, which included the earth. To have created an artifact not in keeping with nature was dangerous. That he built cities at all is surprising, and it must have taken many thousands of years for this man-made creation to have crept into his good graces.

Secondly, surveying and engineering techniques were rudimentary. The first evidence of the knowledge of sueveying is not found in Egypt until about 1400 B. C. , and it was several centuries before its benefits are seen in the layout of cities on a very wide scale.[3] Men had neither the material nor the machines to build bridges, level hillsides or blast out rock. Without the knowledge ~~of~~ or the ability to modify the earth, he had to accept it in its found state and fit his streets and cities to it.

Thirdly, circulation was not the most important function in

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3. Charles J. Merdinger, "Surveying through the Ages," The Military Engineer, XLVI, (March-April 1954), pp. 30-33.

the lives of the city dwellers. Travel tended to be restricted to short intra-city distances. The distance one traveled in daily rounds was seldom far from home. Streets did not need to be long, straight avenues. Movement was slow, so that sharp turns were not treacherous or difficult to make. Streets could well be leftover space after the buildings--the dominant parts of the city--were constructed. Their siting and size were of first-order importance. Functions other than circulation played a heavy part in the streets. Nonmovement spaces need no continuous system. Squares, wide spaces, nooks and crannies formed a part of the street to accommodate these functions. Selling and buying, cooking and eating, resting, working, playing and begging--even making love or one's toilet--were normal activities vying with circulation for a place in the street.

Finally, there was little planning ahead. Towns and cities grew organically, expanding incrementally and contiguously. The street developed a few feet at a time, and not by blocks or miles. Often the presence of a wall around the city prevented outward growth for a long period, during which time the growing interior further warped the already tortuous streets. Intolerable conditions would eventually force the construction of a new wall, within which the gradual, random process would repeat. Though the results of such systems gave good protection against outside invaders--who were at the mercy of the residents in their mazes--it is doubtful if irregular street patterns

were conceived of and deliberately put down with this end in mind.

If the pre-industrial irregular pattern is easily explained, how can one account for the modern one? Modern men are not submissive to nature. Their surveying and engineering skills are not crude and limited. Transportation is vital to their lives, and they can and do plan their communities now. Yet, in spite of these facts men have returned to the irregular pattern. Why? It may be that men have learned something from their departure from the natural order, which excursion lasted roughly from the fifteenth to the beginning of the twentieth centuries.

The modern irregular pattern may have been caused by:

1. Reaction to the visual monotony that can result from an indiscriminate use of geometric patterns; a renewed appreciation for the value of variety in men's lives.

2. More sophisticated planning that could demonstrate the economical advantages inherent in adapting routes and structures to their sites.

3. The control of traffic as the uppermost factor to be considered in street planning. Stopping streets were designed to prohibit traffic, and moving streets were built for the continuous, smooth movement of wheeled vehicles. As the curved, irregular pattern discouraged enemies in the old cities, it performs a similar function in barring through traffic from the modern neighborhood.

The irregular pattern, whether old or new, would seem to be of limited adaptability. That is, its original intent dictates its arrangement and scale according to function--the function that prevails at the time of inception. The ancient and Medieval streets were for pedestrians and a few slow vehicles and that is what they are best at carrying. The modern subdivision with winding streets is for intra-community automobile traffic and little else. The modern urban freeway is likewise good only for the purpose for which it was designed.

Another side-effect of irregularity is the nonuniformity and odd shaping of blocks. Though an irregular plan may be able to use land more efficiently than a geometric pattern can (in terms of percentages of space devoted to street use) the outlines of the blocks, while larger in area, may be such as to offset any areal gains. This may not be critically important in areas of single-family residences, but again this assumes a one-time function of the land. Intense building on the site at a later date, if it should come, would be handicapped.

People not familiar with the irregularly-patterned city may have difficulty finding their way about. Mis-orientation can easily result without the benefit of a known axis for reference. On the other hand, recognition of an area once seen is made easier since all parts

of the city are slightly or radically different.[4] It would seem, however, that finding a destination or route within a random system would generally be the more difficult. As the seeker traverses the area, each intersection may not add to his understanding of the system, as it might in a geometric one.

These are not offered as value-judgements of the irregular street pattern, but are mentioned to point out some factual consequences that are sometimes forgotten or discounted. The irregular pattern has its merits and its place. Of this there can be no doubt, but it may also have its shortcoming and limitations.

4. The writer can attest to the negligible benefit that this factor affords. The irregular pattern of Bel Air, A Levitt community near Bowie, Maryland, has served to confuse and to nearly frustrate several attempts to visit a resident near the center of this 5000-home development.

CHAPTER SEVEN

GEOMETRIC PATTERNS

The general definition of an irregular pattern as being one that lacks ordered repetition implies that patterns with repeated relationship should constitute the other broad category of street arrangements, namely geometric patterns, as we shall call them here. This is approximately correct, but of course neither grouping is mutually exclusive. No definition can be perfect, and there will be some street patterns which could conceivably be considered either irregular or geometric, depending upon one's definition, or the interpretation of the definitions and standards applied. There are some who would call Mohenjo-Daro, for instance, regular or geometric.[1] And, if their definition of regular patterns includes those that are partially planned and roughly geometric, then they are quite correct. Here, however, a stricter and higher standard is considered necessary to qualify for the label "geometric."

A geometric pattern will tend to have characteristics that are the exact opposite of those attributed to the irregular plan, i.e., its streets will normally be straight or of constant curvature, there will not be variations in width within the same street, distances between

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1. Cf. Thomas Adams, Outline of Town and City Planning, A Review of Past Efforts and Modern Aims (New York: Russell Sage Foundation, 1935), p. 42.

streets will be the same or will follow some order of variation, and relationships in general will be duplicated throughout the area. It is almost possible to state that all geometric patterns are planned, but this would erroneously exclude those cities that exhibit regular features that were apparently not consciously pre-determined. There are probably numerous such towns and communities that have taken their cue from geometric examples before and around them, and have grown more-or-less in imitation of their planned predecessors. The United States is covered with towns and small cities whose growth consists of adding rectangular blocks as needed. This phenomenon owes its origins, in great part, to the American system of rectangular land surveying which came about as great expanses of public lands were added to the nation's growing geography.[2] The reverse situation was noted in the last chapter where it was seen that irregular patterns were not necessarily unplanned. It is therefore impossible always to apply the terms planned and unplanned in place of geometric and irregular.

The formal arrangement of streets must have occurred to men rather early in the process of city building, though they were loath, or unable, to experiment with it at first. As men commenced their assertion over their environment they gradually departed from

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2. William D. Pattison, Beginnings of the American Rectangular Land Survey System, 1784-1800 (Chicago: University of Chicago Press, 1957).

the form supplied them by nature and created their own. The god of the ancient society, the conqueror and emperor of the classic age, the king in Renaissance times, and the speculator of the nineteenth century manifested their desire to be creators in their own right by making artifacts that were un-natural. This was the obvious method of demonstrating mastery over the earth--to put down cities that violated the pattern of the earth. But, whatever the hidden or open reasons, the orderly layout of cities has been an obsession and an occupation of men from very early times. Though this trait shown signs of tempering or diminishing with the informal patterns of today, it is still very much with us--as remnants of other periods with which we must live, and as the continuing architectural productions of our time.

The geometric form as we would define it--narrowly--takes only two basic patterns--the grid and the radial system. The former is by far the more ubiquitous, probably appearing to some extent in the vast majority of all cities. The latter is much less in evidence, but is never-the-less a significant form, by all counts.

The grid system, which is simply the arrangement of straight streets intersecting at right angles,[3] is very old, very common, and

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3. This is the traditional arrangement in the overwhelming majority of grids, but there can be a grid effect with non-right angular intersections. This would result in rhomboidal blocks and difficult turnings.

very much maligned. The concept of rectangularity may have its origin in agriculture. When the plow was invented the soil could be tilled in straight and repetitive patterns on flat terrains. Or, the use of straight poles to form the walls of buildings could have suggested the preferability of the right angle as the basic element.[4] The rectangle, to the Etruscans, was cosmic law. In any event, the grid has been a favorite of city-builders for centuries. Its continued use must certainly reflect some good aspects, else it should have faded long ago. What are its advantages?

First of all, it is simple to lay out. A city with a grid system is assured of being able to continue its pattern indefinitely without recourse to the talents of a professional planner. As Lewis Mumford has put it:[5]

> "If the layout of the town has no relation to social activities and needs other than those of the surveyor, the real estate speculator, and the jerry-builder, the simplest means of organizing it topographically is by means of rectangular blocks: blocks of identical size, separated by streets and avenues of standard widths."

Secondly, it produces convenient and useful parcels of land. Blocks can be subdivided uniformly and with equality. There is equal access to all points on the street, and all points are equal.

Thirdly, it is easy to find one's way around in it. Orientation

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4. Lewis Mumford, The Culture of Cities (New York: Harcourt Brace & Co., 1938), p. 52.

5. Ibid., p. 183.

is no problem, even to the stranger.

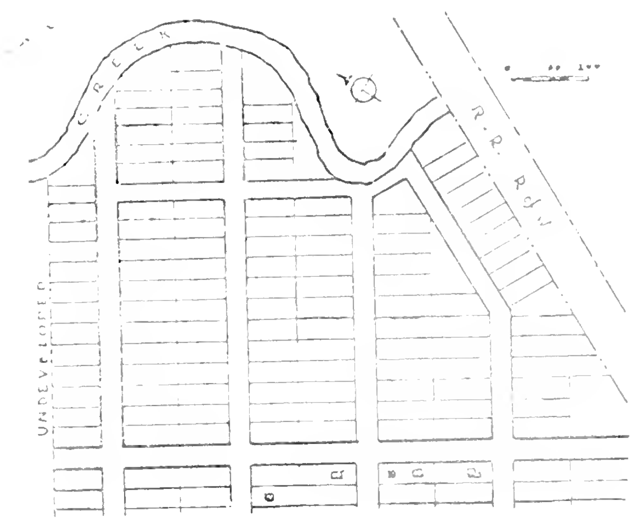
As will be shown later, there may be other advantages to the rectangular pattern when it is modified for the needs of a specific neighborhood or to control traffic. But as to direct elements of the street, these are the primary ones. Now, as to the deficiencies:

First, a grid system uses large amounts of land--as much as any other system, or more, for a given width of street and given degree of access. Fig. 15 demonstrates this fact.

Secondly, the grid can be a very monotonous thing. Applied without imagination and variation, the rectangular pattern places the whole burden of esthetics upon the land use, architecture and flora of the city.

Third, it is limited--for best results--to relatively flat land. Placement of a grid upon hilly and rolling terrain is wasteful and does not use the site to best advantage.

A final troublesome feature of grids that sometimes leads to queer situations, is the problem of joining two patterns not similarly oriented. Where grids in a city have developed their axes individually along arteries leading into the central business district, they will not normally merge with one another very well. The result is a rather ragged seam between the neat rectangular systems. Streets are contorted and abruptly ended, forming a strip of irregularity, which cuts up land inefficiently and tends to form a dividing line within the city.



112 Lots

About 20% less street area
115 lots
Room left over for green space

Figure 15

The Grid Pattern as a user of [illegible] from Carl C. Mack, "Subdivision Programs [illegible] FAA," Insured Mortgage Portfolio, (F[illegible]rter 1948), p. 15.]

To call a pattern a grid is really being too general, since there can be tremendous differences among them. Starting with the basic characteristic of all grids--straight streets intersecting at right angles--an infinite number of patterns can be possible by varying certain direct and indirect elements of the streets. Some of the things that can be manipulated, for instance, are:

1. The distance between parallel streets. Just because a system is grid-like is no reason that streets have to be equidistant from each other. See Fig. 16. When variable-spaced streets in one direction

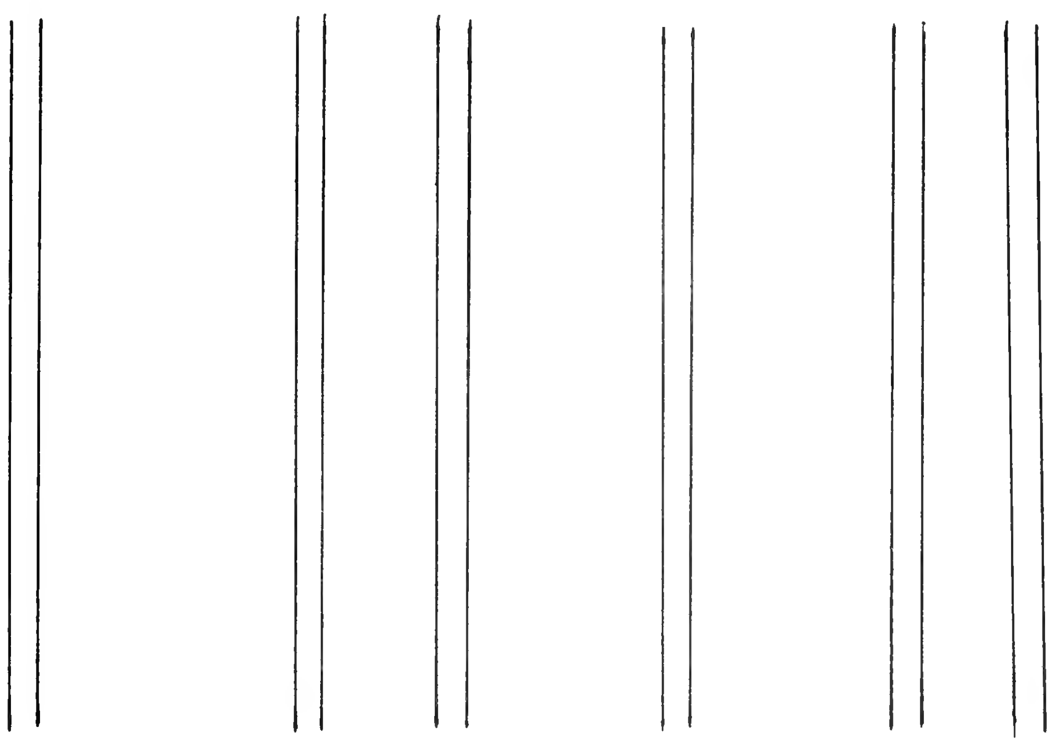


Figure 16

Varied spacing of parallel streets.

are crossed by evenly-spaced streets in the other direction, an interesting arrangement of block sizes and shapes can be instituted, allowing for a mixture of buildings and activities in the area. See Fig. 17 for an example of this effect.

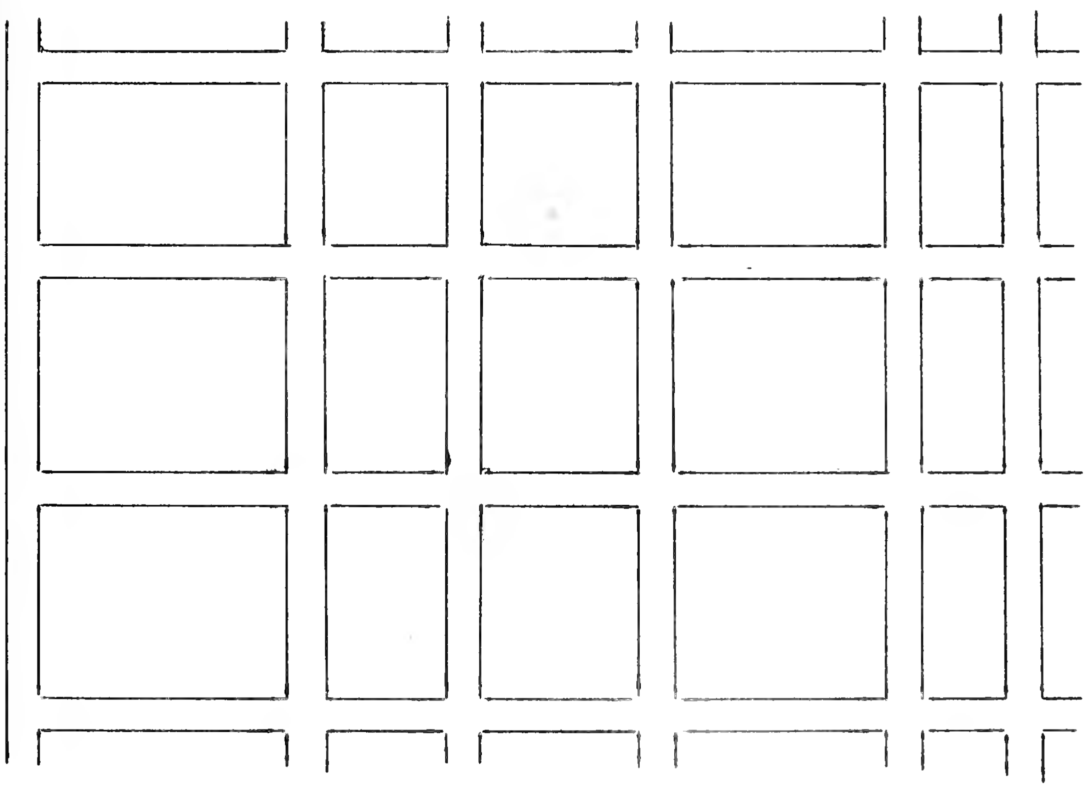


Figure 17.

Variable-spaced streets spanned by regularly-spaced streets at right angles, producing blocks of several shapes and sizes.

The extreme opposite of such free play with dimensions is the ultimate in grids--the checkerboard. In this plan, not only are distances between parallel streets the same, but the same distance holds for the streets in the other direction. The result is a

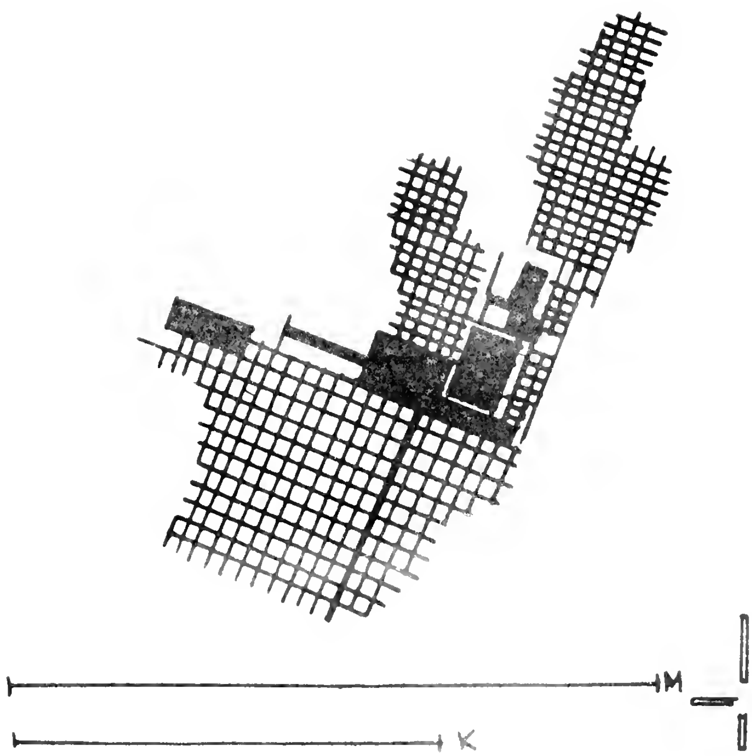


Figure 18.

Miletus, in what is now Turkey. One of the earliest checkerboard patterns, founded about 500 B. C. by Hippodamus. [From Richard S. Wurman, The City, Form and Intent (Raleigh, N. C.: Student Publication of the School of Design, 1963), dwg. no. 24.]

pattern of square blocks, which is among the least efficient ways to parcel land. Moreover, such a system lacks a dominant orientation. Miletus, laid out by Hippodamus about 500 B. C., was one of the first examples of the checkerboard. See Fig. 18.

2. The lengths of streets. By skilfully controlling the lengths of streets the grid can accomplish almost as much control over traffic as can the irregular pattern. Long streets that may traverse the entire area can be supplemented by shorter ones that serve the local intra-community purposes as "units-in-motion" space. The termination of straight streets is not only an effective traffic control device, but is also a good visual relief among otherwise monotonous straight, interminable lines. Fig. 19 is one suggested way of varying the lengths of grid streets.

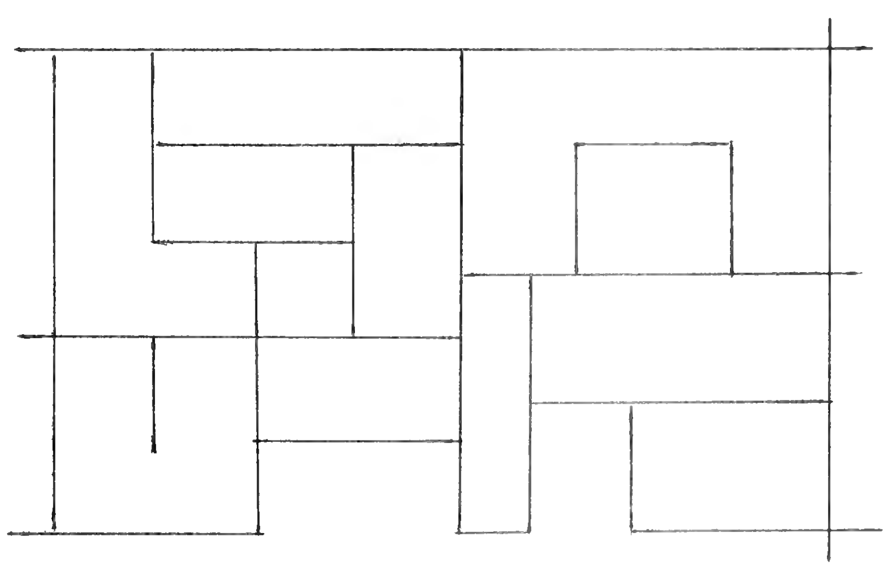


Figure 19.

Streets of various lengths within a grid system.

3. The widths of streets. An assortment of widths to suit the purposes of the street is very desirable. This does not necessitate simply making the long, through streets wide and the others of lesser magnitude. A long narrow street can sometimes be cleared of parking on both sides, given a favorable traffic control lighting pattern and made one-way to become a very high-capacity street. On the other hand, a wide street with perhaps a tree-lined median strip can also make an efficient and attractive artery. By a judicious use of various widths, the grid can respond to a multiplicity of traffic volumes and types.

4. The land use of the enclosed blocks, the facade and the type of traffic. These three factors--the indirect elements of the street--are fully as vital to the success of the grid as the direct elements. Let any who doubts the value of these nonstreet factors examine the street plans for New York City. He will find the same grid pattern over much of the whole island of Manhattan. Yet there can be a world of differece among these street patterns when one drives or walks through them. Movement is easy and enjoyable in some places, difficult and depressing in others. The difference is in things that have nothing physically to do with the actual street pattern. The grid is not inherently objectionable. It can be made an asset, but by itself it is doubtful if it could ever be the spoiler.

Turning to the radial system--the other general geometric

pattern--we must note at the outset that it is an incomplete pattern by itself. A radial system of circulation must include fragments of some other patterns as a supplementary circulation network. The arrangement of streets so as to converge on a point or an area cannot by itself carry out the function of any sizeable or active area. Within the interstices of the diagonally-oriented routes a supporting, secondary system, be it irregular, circular or grid, is required. (See Fig. 21.) The complete radial pattern, therefore, is a system of major converging streets together with minor connecting streets. We should not allow the dominant appearance of the maverick diagonals to divert appreciation for its supporting essentials. A pure radial pattern would be fairly useless.

The consciously-planned radial pattern is largely a product of the Renaissance. This was the period, from the fifteenth of the eighteenth century in Europe, in which royalty and monumentality sought an urban framework suitable to their grandeur. The radial pattern, with its natural emphasis on a dominant central place, was the answer. It had appeared in theory many years before in Greek and Roman writings about utopias and ideal cities, but only after the middle ages did cities actually take the radial form. It blossomed promisingly for a short reign, spreading to America and other

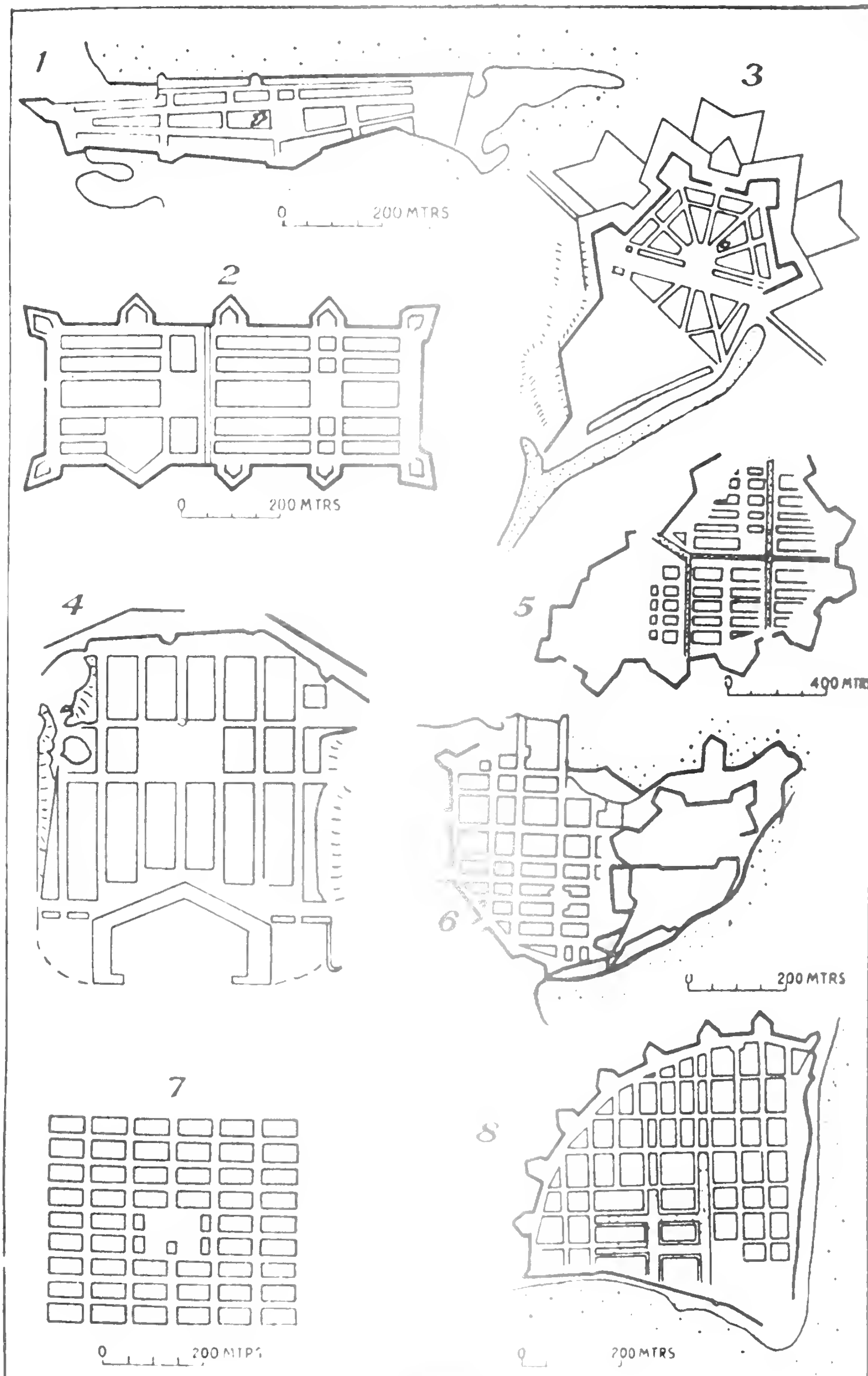


Figure 2[illegible]

Geometric patterns, especially the grid, flourished in seventeenth century Scandinavia: 1. Christianope. 2. Christianstad. 3. Gluckstadt (lower Elbe) 4. Jonkoping. 5. Goteborg. 6. Christiania (Oslo). 7. Frederisks sund. 8. Fredericia (East Jutland). [From Robert E. Dickinson, The West European City (2nd ed., re.; London: Routlegge & Kegan Paul Ltd., 1961), p. 441.]

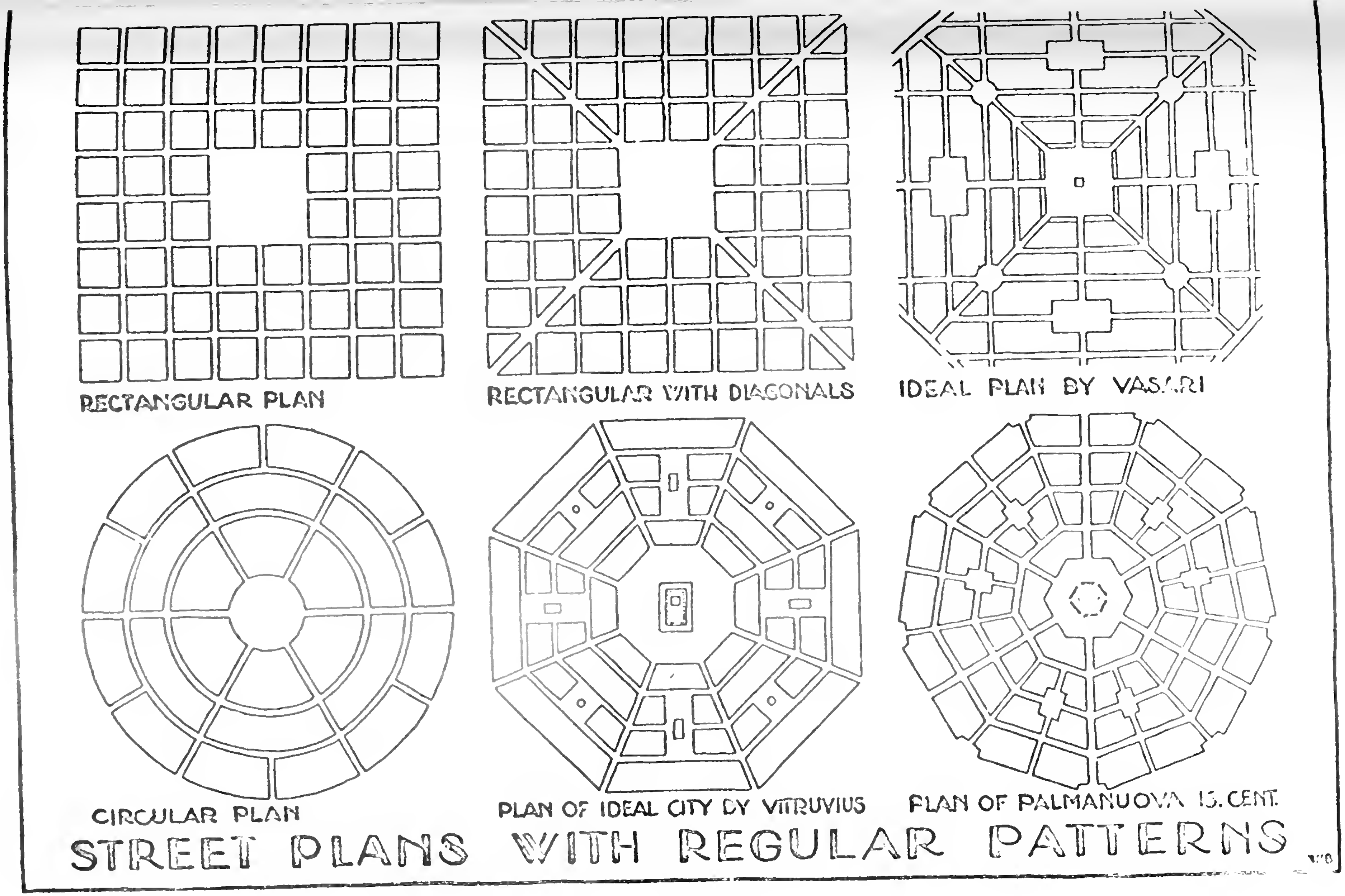


Figure 21.

Idealized schematic drawings of geometric patterns, especially radial patterns. [From Thomas Adams, The Design of Residential Areas (Cambridge, Mass: Harvard University Press, 1934)]

countries, such as Australia.[6] It has now lost favor with planners to a large extent. Baron Haussmann's surgical operations on the city of Paris were among the last of this Baroque city form.[7] The radial is evidently not the final answer as a functional pattern. Conceived partly for visual effects, even this aspect appears to be derided in recent years in some architectural quarters. A group of radial city plans that were the typical avocation of would-be planners of the Baroque era are shown in Fig. 22.

The following are the principal characteristics of the radial system:

1. It has, or tends to create, a strong central nucleus or focus. This central attraction was originally the palace, but it may be a civic center, a church, a capitol building or a major area of the city--as the central business district.

2. Orientation of the primary streets which should carry the massive types of traffic is between the center and the periphery of the area. This creates a traffic problem which intensifies as one approaches the center.

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6. In the United States, Annapolis, Maryland; Washington; Buffalo; Detroit; Indianapolis; and Madison, Wisconsin either were planned, or planned and built, with radial patterns.

7. Napoleon III commissioned Haussmann to rebuild Paris, then badly wanting for civic and sanitary improvements in the 1850's. This has been called "The Swan Song of the Baroque" by Gallion and Eisner in <u>The Urban Pattern</u> (Princeton, N. J. :D. Van Nostrand Company, Inc. ,1963), p. 55.

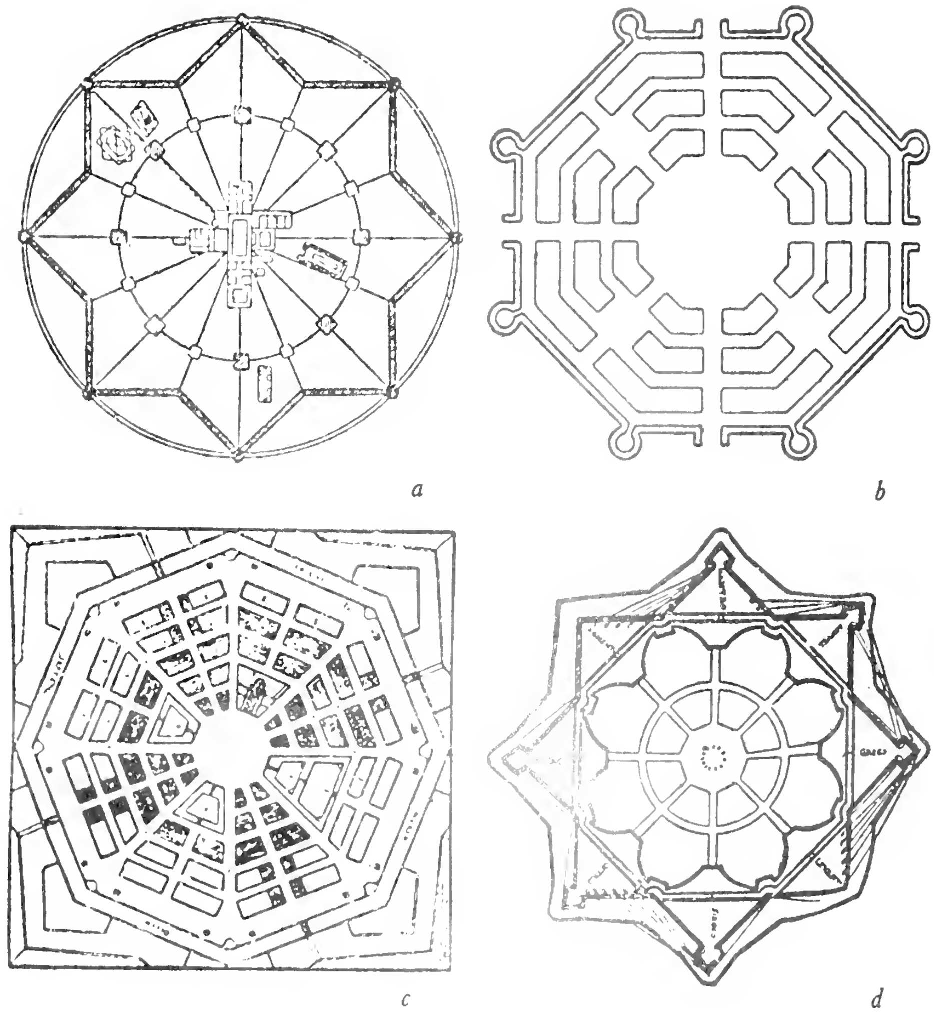

Figure 22.

Some "ideal" city street plans devised by Renaissance planners for the pleasure of the court, or for themselves. [From Robert E. Dickinson, op. cit., p. 422.]

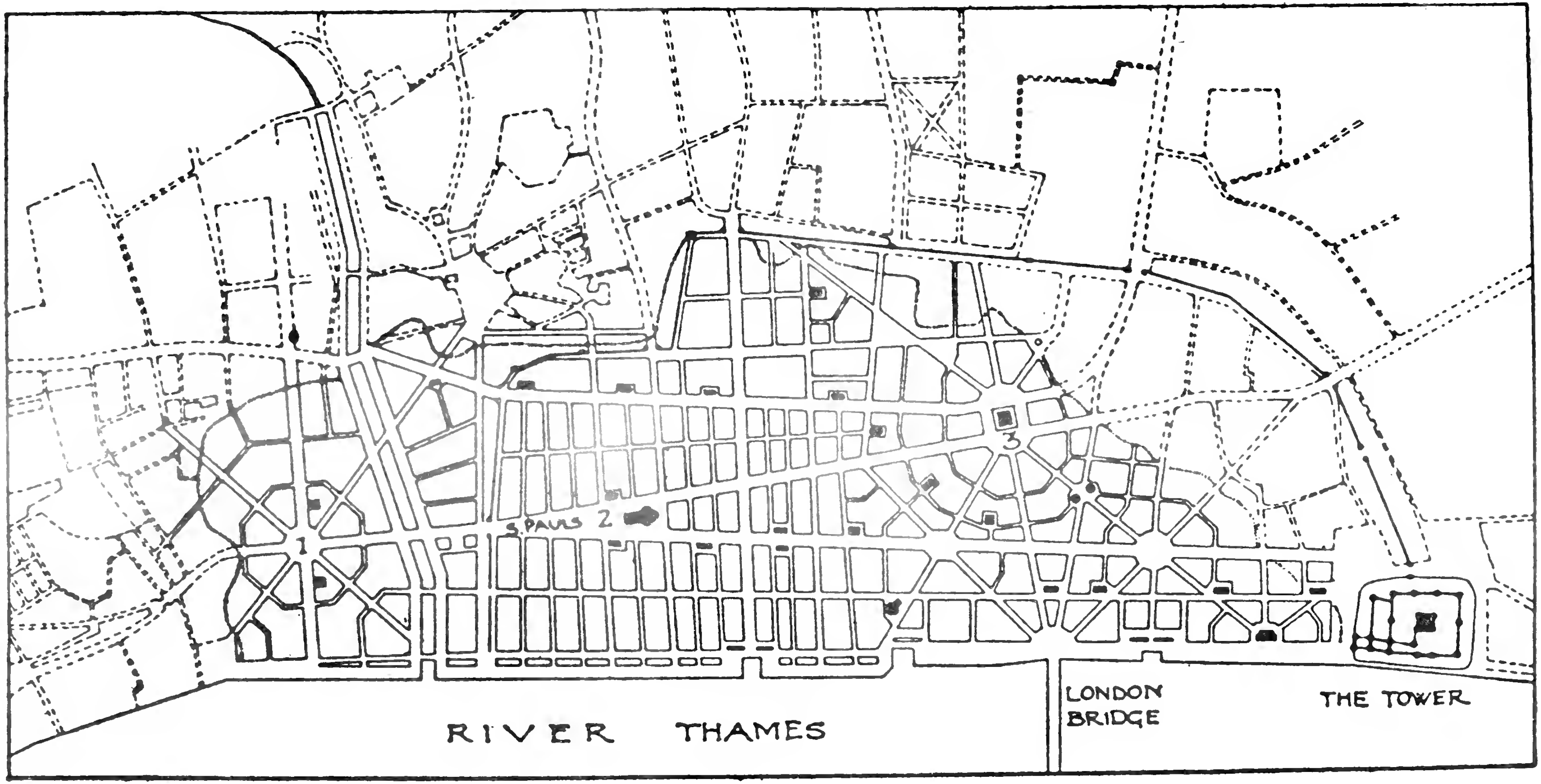

Figure 23.
Sir Christopher Wren's geometric plan for London after the fire of 1666. This would have been a great improvement over the congested, cramped conditions that existed before, London having outgrown its Medieval, small-town character. The plan was not adopted. [From Frederick B. Hiorns, Town-Building in History (London: George G. Harrap & Co., Ltd., 1956), p. 286.]

3. There is only slight flexibility or adaptability in the system. Alternate routes, except by out-of-the-way travel, are not available as in the grid system.

4. Interior spaces are shaped in unusual ways.

5. It appears best suited for large scale use for inter-area traffic and must be supplemented by other patterns for intra-area travel.

As mentioned previously, both the grid and the radial pattern have appeared organically--without being planned that way by man. The original crossing of several long distance routes that have given birth to many an urban form is of course an "irregular" radial system. Likewise, rectangularly-shaped structures in juxtaposition will often emerge in grid arrangement. In fact, one famous city planner has suggested that these two patterns are the natural patterns of human activity in a geographical setting, with the grid fitting the small, local end of the scale, and the hexagonal radial connecting the larger segments of a region together.[8] See Fig. 24 for a graphic representation of this unique idea.

Whatever form human habitants take in the future, it is doubtful that geometric patterns will be absent from the landscape.

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8. See C.A. Doxiadis, "Ekistics and Traffic," Traffic Quarterly, XVII, (July 1963), pp. 439-457.

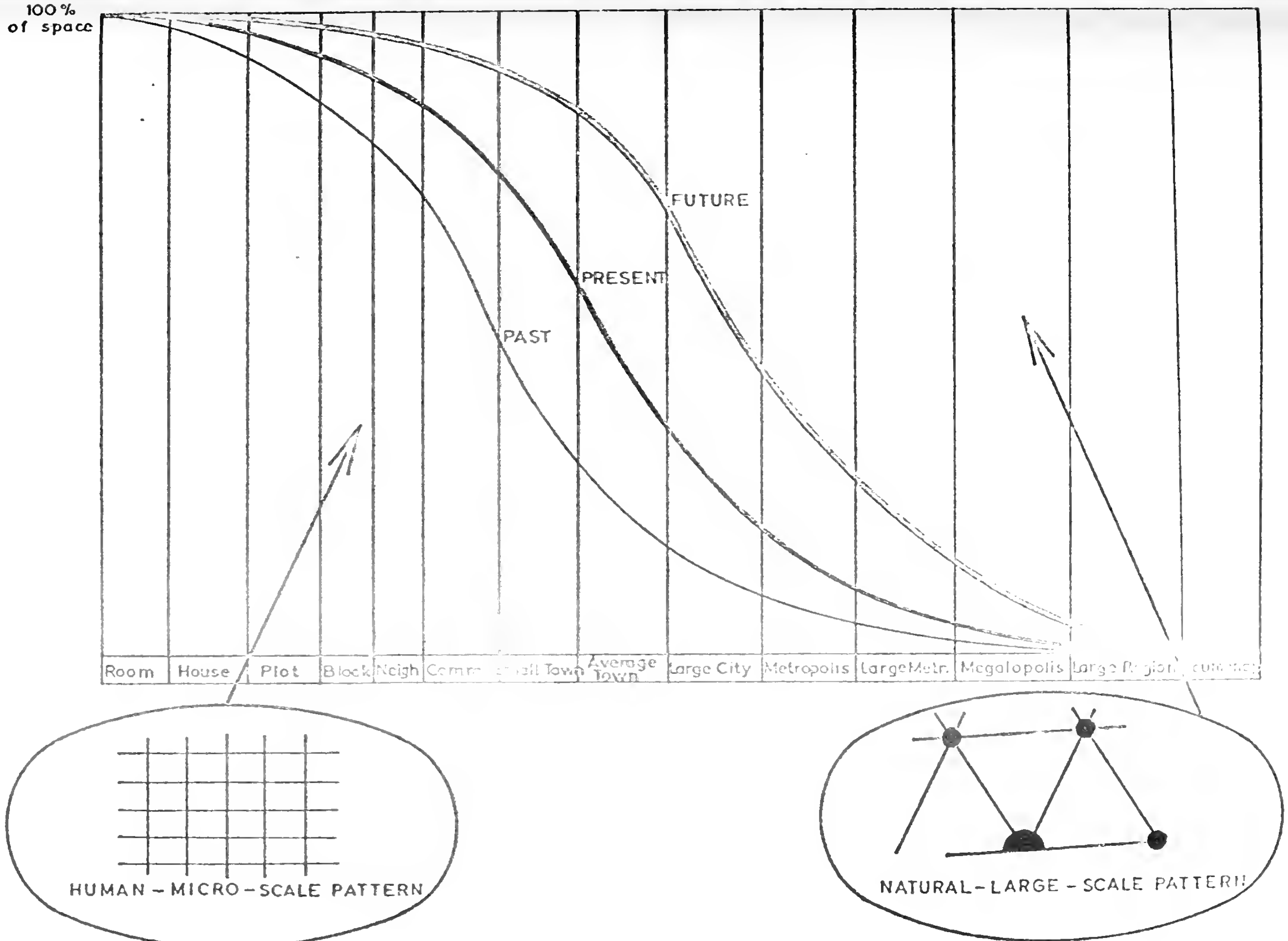

Figure 24.

Open space divided between large and small scale activities. The hexagonal pattern serves the former and the rectangular pattern the latter, according to the proponent of this concept. Note the trend that the dividing line is taking. [From C. A. Doxiadis, "Ekistics and Traffic," Traffic Quarterly, XVII (July 1963), p. 449.]

They have proven that they can be both efficient and attractive when appropriately designed and used. Neither the irregular or the geometric patterns should be categorically labeled with qualitative adjectives intended to apply in all cases. The changed forms of transportation and of land use that we have witnessed within the past half century should be a warning against the temptation to elevate or relegate any system of routes to a position of perfection or oblivion. The dimension of time can enhance, or undo, the worst and the best of our physical dimensions.

PART III

ANALYSIS

Case studies of several patterns from real cities. Examples of irregular and geometric patterns, old and new, from various parts of the world. Pertinent information about each city and its streets is provided for examination and analysis on the basis of what has been presented in Parts I and II.

CHAPTER EIGHT

CASE STUDIES--IRREGULAR PATTERNS

Six cities or parts of cities are considered in this chapter. Each is an example of a type of irregular street pattern. They hopefully will illustrate several points about the irregular pattern--its variety, its endurance through time, its functionality, its advantages, as well as its shortcomings and misuses. These particular cities were not chosen because they are notably good or bad examples of street arrangements, but because they are more-or-less typical. Many other patterns could have been shown, and could undoubtedly demonstrate the same points. Any object looked at analytically can teach its viewer something.

The same set of facts is given for each city. These are the minimum facts considered necessary for a moderately rigorous analysis. For a more penetrating study of any one pattern, additional research is of course to be suggested.

The cities are, in order of their appearance:

Mohenjo-Daro

Middleburg

Stamford

Kendall Park

Reston

Brasilia.

1. Mohenjo-Daro (Figure 25)

Location: In the Indus valley--now Northwest India

Period: Ancient--Probably around 2000 B. C. and earlier

Type: A capital and inter-empire trading center

Population: 70,000

Traffic: Pedestrian and animal

Pattern: A "Shattered" semblance of grid-like formations, producing an irregular effect.

Remarks: Mohenjo-Daro and its counterpart to the northeast, Harappa, were possibly the twin capitals of the Indus civilization.[1] They resemble each other in many ways. Defensive works do not appear to have concerned these people. The circulation level was probably fairly high, but there were few wheeled vehicles to create congestion. The dividing lines between streets and houses are difficult to distinguish because they flowed together so readily. The functions of the street and the enclosed spaces overlapped. Streets were short, straight, ending abruptly. Grades were overcome by steps. There were several main thoroughfares that seem to have been planned and carefully laid out. Space used principally for circulation is estimated at ten per cent or less.

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1. Several books of urban history and city planning contain good accounts of the Mohenjo-Daro and other Indus civilizations. Information herein comes generally from Jacquetta Hawkes and Sir Leonard Wooley, History of Mankind, Cultural and Scientific Development, Volume 1: Prehistory and the Beginnings of Civilization (New York: Harper and Row, 1963), pp. 451-458, which offers a concise, reliable rendering.

Figure 25

Mohenjo-Daro

[From Paul Zucker, Town and Square (New York: Columbia University Press, 1959), p. 21.]

2. Middleburg (Figure 26)

Location: Netherlands

Period: Medieval--Founded about 1100 A. D.

Type: A trade center of the Hanseatic League

Population: Under 20,000

Traffic: Pedestrian and animal-drawn carts and wagons

Pattern: A tortuous irregular arrangement

Remarks: Here a crude radial-circular pattern has emerged from the effects of the wall and a central nucleus. Middleburg was built on flat land, so the topography could not have been a limiting factor in the patterning of the streets. The inner ring-shaped street is built upon the remains of an early wall. Also the route following along the last series of fortifications is evident. The city seems to be turned in upon itself for mutual security and spiritual unity. It is an organic creation with no thought for the spectacular. Streets are of many different widths, lengths and directions depending upon their purpose. Circulation space appears to occupy no more than ten to fifteen per cent of the area.[2]

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2. Frederick R. Hiorns, Town-Building in History (London: George G. Harrap and Co., Ltd., 1956), pp. 157-160, was the best source for information about Middleburg.

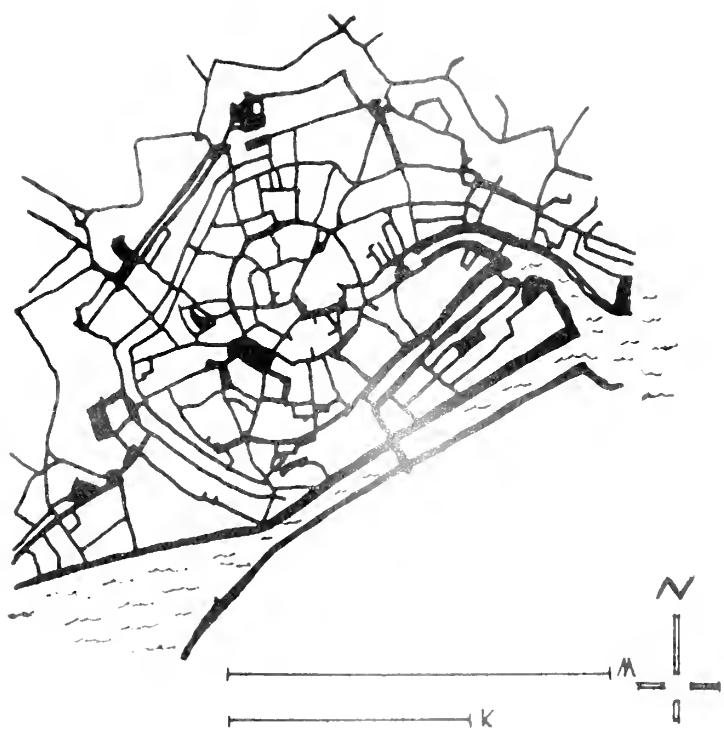

Figure 26

Middleburg

[From Richard S. Wurman, et al., The City, Form and Intent (Raleigh, N.C.: Student Publication of the School of Design, 1963.)]

3. Sub-Division of Stamford, Connecticut (Figure 27)

Location: New England, United States

Period: Modern--1930's

Type: Residential; single-family houses on individual lots

Population: 300-600

Traffic: Automobile and Pedestrian

Pattern: A planned irregular system

Remarks: This is typical of the modern irregular pattern that is found in many new residential parts of American cities. It does not separate completely pedestrian and vehicular traffic, but it discourages heavy, through traffic. Although the density is low, for a given density and lot size, this scheme allows an efficient usage of land. It is impossible to tell from this figure, but the streets probably give consideration to contours in their layout. Widths are adjusted to fit traffic volumes. Land devoted to circulation appears to be well below twenty per cent.

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3. No references located for this example; Figure 27 taken from American Society of Civil Engineers, Land Subdivision, A Manual Prepared by the Committee of the City Planning Division on Land Subdivision Manual (New York; ASCE, 1939).

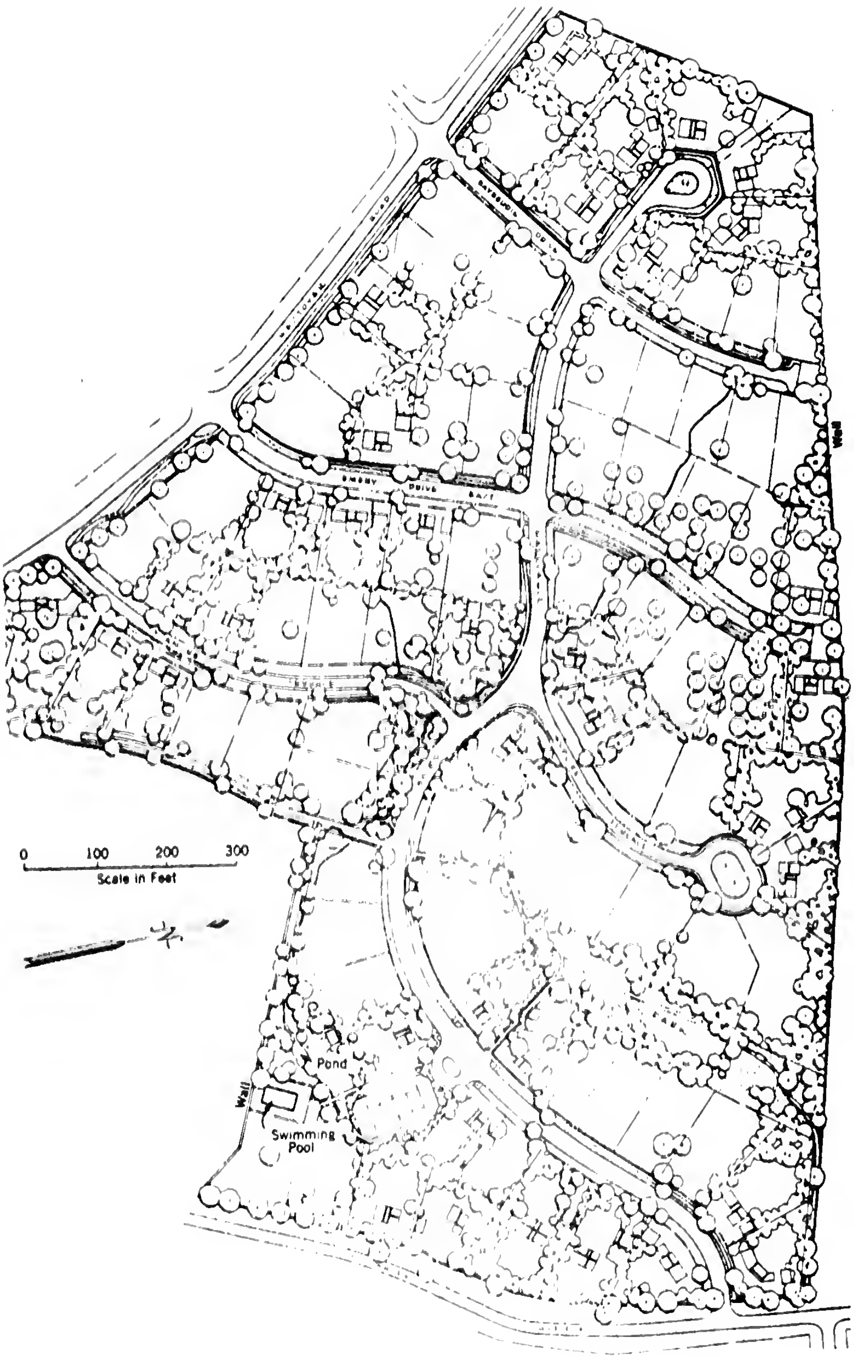

Figure 27

Stamford, Connecticut Sub-Division

4. Kendall Park, New Jersey (Figure 28)

Location: Middle Atlantic, United States

Period: Modern--1950's

Type: Residential: single-family houses on individual lots built as a mass development

Population: 6000

Traffic: Automobile and Pedestrian

Pattern: A planned irregular system

Remarks: Another planned, irregular pattern; this one conceived of and built by one developer on a large scale. The gently rolling topography would have allowed almost any arrangement of streets, but the irregular one is intended as a reliever of monotony which is a real possibility where the houses are all alike and there are almost no trees to break the view. The homes located on the two through streets of the area are subjected to fairly large volumes of fast traffic. Though elementary schools are within walking distance of all points, shopping facilities are not. All streets are the same width. Pedestrian walks are in all instances immediately adjacent to streets. Circulation rights-of-way occupy about twenty per cent of the area, yet even intra-community communication is made difficult by the size of the development, the absence of direct pedestrian ways, and the circuitous routes.

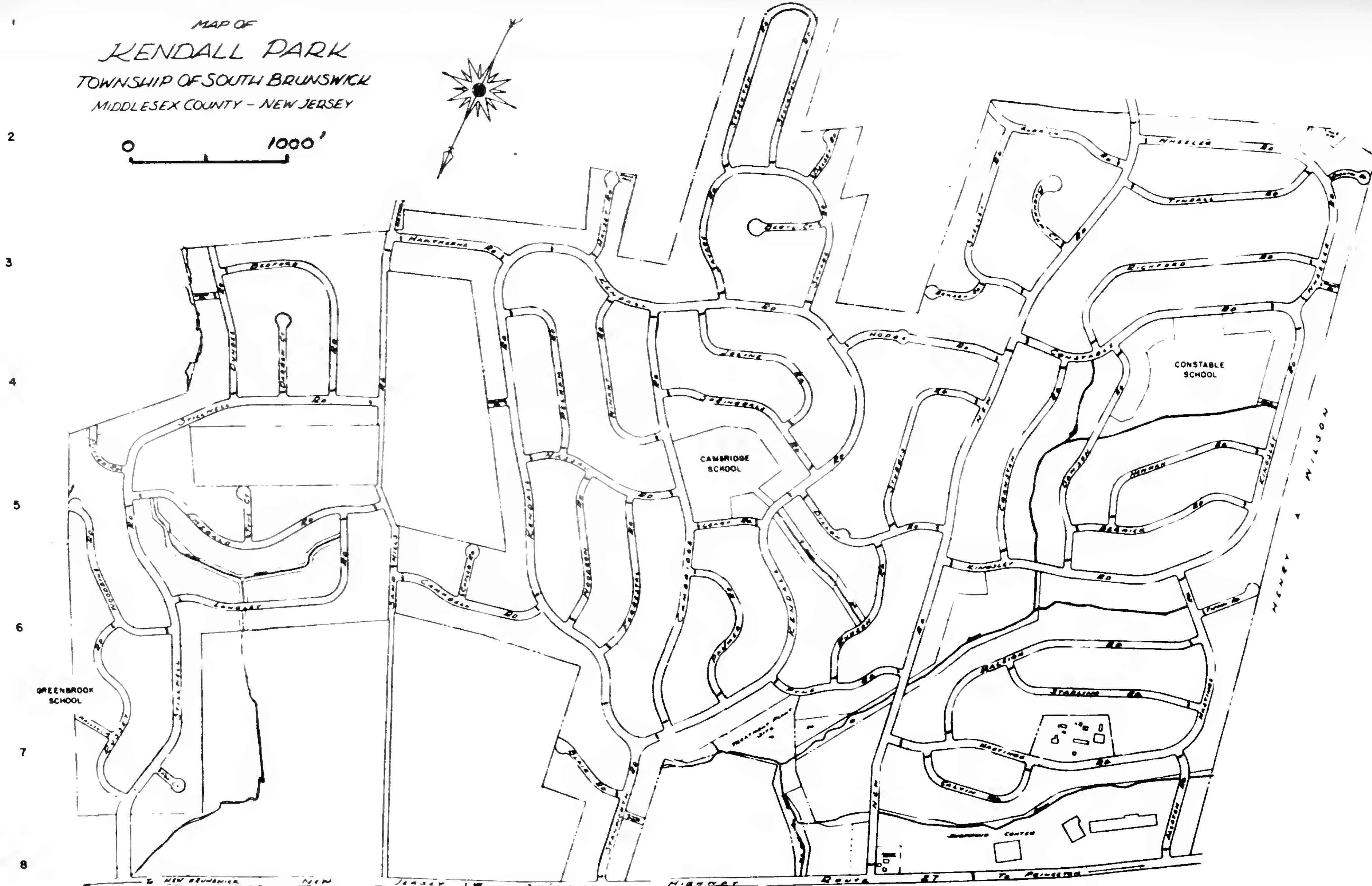

Figure 28
Kendall Park, New Jersey

(From Map Distributed by League of Women Voters of South Brunswick.)

5. Reston, Virginia (Figure 29)

Location: Middle Atlantic, United States

Period: Future--Modern; 1960's

Type: Self-Contained complete city--a satellite of Washington, D. C.

Population: Planned for 75,000 in 1980

Traffic: Mixed; Truck, Automobile, Bicycle, Horse, Pedestrian

Pattern: Irregular, with several systems for separation of traffic

Remarks: This city is under construction on 6,800 acres, 18 miles west of Washington, D. C. It is the first city in the United States to be built as a part of a recommended regional development plan for a major metropolitan center.[4] It will consist of seven villages of about 10,000 persons each. Each village will have a village center of shops and community facilities. In addition, a larger town center of 100 acres of commercial activities and 900 acres of industrial and office space have been set aside. There will be over thirty varieties of housing for all tastes, prices, and ages, designed by many different architects. Walkways and roads are to be completely separated. Bicycle paths and bridle paths are to be included. Parking for cars is to be behind or under buildings. Street widths will vary to meet the expected capacities, and streets will be located functionally. Circula-

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4. All factual information about Reston taken from brochures and other material furnished by Simon Enterprises, owner and developer of Reston.

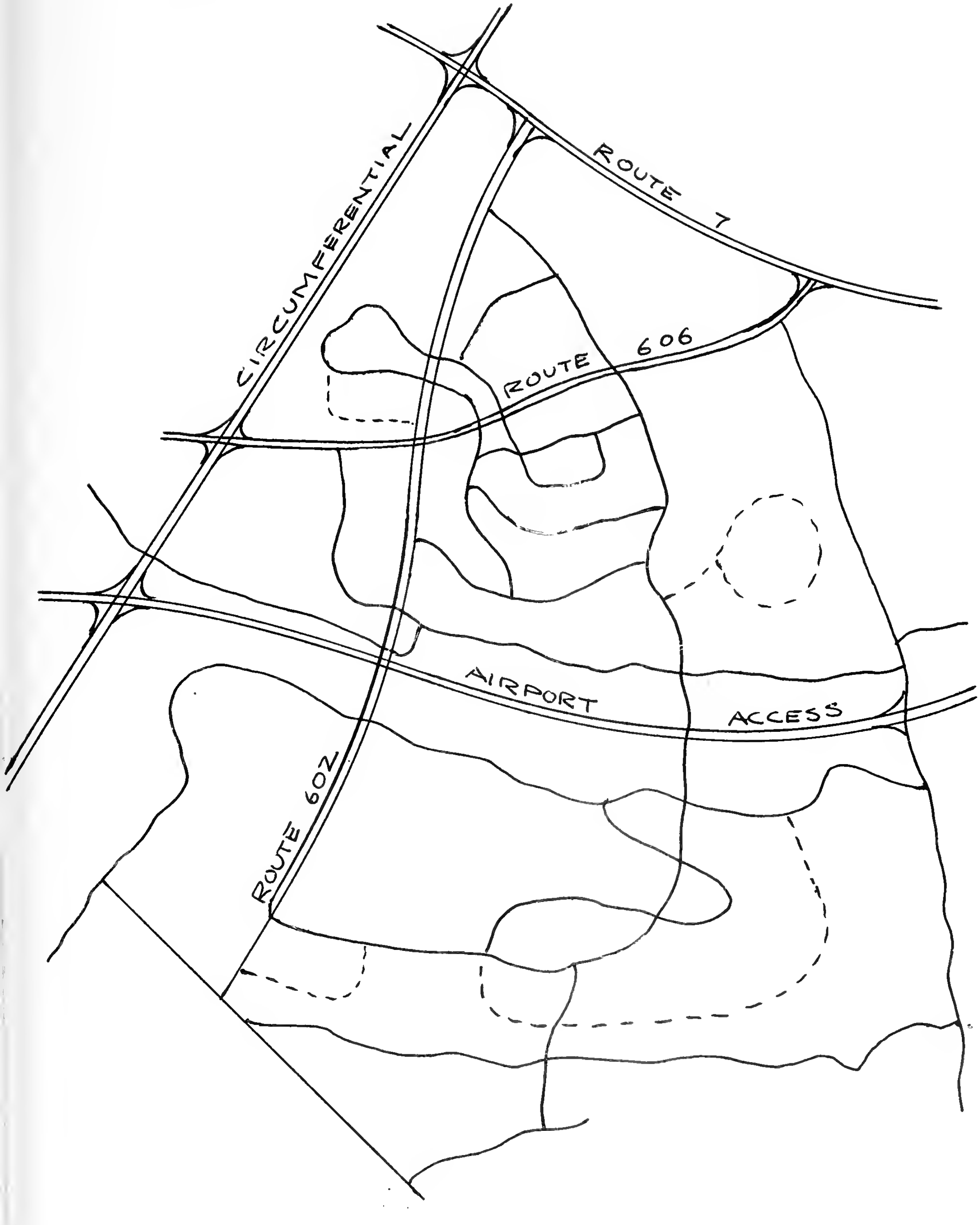

Figure 29
Reston, Virginia

tion routes will follow contours generally and will occupy about ten per cent of the land area. Planners for Reston were Whittlesey and Conklin.

6. Brasilia (Figure 30)

Location: Central Brazil

Period: Future-Modern

Type: A large, capital city

Population: Planned for over one million persons eventually

Traffic: Mixture of mass transit; air, automotive, bicycle and pedestrian with separation of each type insofar as possible

Pattern: Planned Irregular

Remarks: The plan for Brasilia could be considered geometric because of symmetry in the layout of several of the main avenues. However, the total pattern, as well as many of its parts, is irregular. Brasilia was begun in 1956 and is not yet completed. It is intended as the new capital of Brazil in the interior wilds of the country. The uniqueness of Brasilia comes from its reliance upon two intersecting boulevards for most activity. A straight boulevard, 3.7 miles long and 1,150 feet wide, is to serve all public buildings. A gently curving avenue at right angles to this will be for residential purposes. The scale of the whole city is tremendous--a throwback to the finest traditions of monumentality. Brasiliâ's prize-winning plan is that of Lucio Costa.[5]

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5. All information about Brasilia taken from Schneider, op. cit., pp. 344-353.

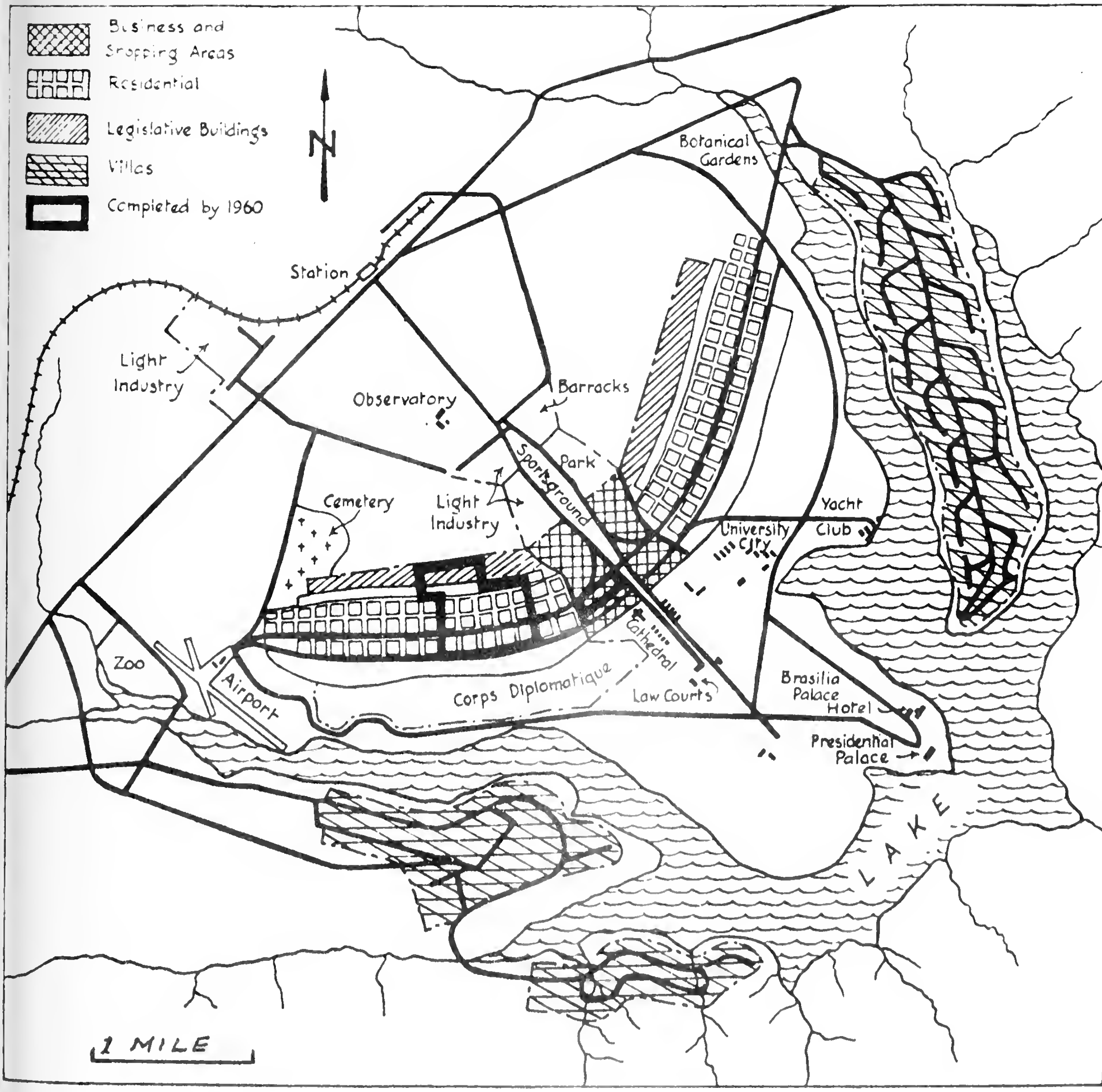

Figure 30

Brasilia
(From Wolf Schneider, op. cit., p. 348.)

An analysis of just these six irregularly patterned cities reveals several interesting facts. These may be listed as follows:

1. There are many different forms of irregular patterns. The scale and grain of each of these examples is different. Each irregular pattern is an individual type.

2. Irregular patterns can be successful or unsuccessful in general, and can include both good and bad features within one pattern.

3. Land used for streets is not generally excessive.

4. An irregular pattern can be designed for any mode of surface transportation.

5. While the ancient and Medieval irregular patterns were evidently fine for their purposes in their days, they probably cannot be adapted to modern motor vehicular use efficiently.

6. It is possible to design a modern irregular pattern similar to the old organic ones and have it function either well or poorly.

Though the irregular pattern is very old, it still shows signs of life. Planners have returned to this form for some of the most famous and best-reputed modern cities of the present day. Its continuing vitality is based on its flexibility in response to various stimuli. Though it is not a panacea it is undoubtedly here to stay for a long, long time.

CHAPTER NINE

CASE STUDIES - GEOMETRIC PATTERNS

Six examples of geometric street patterns from as many different cities are considered in this chapter. As in the previous chapter, each is intended to show the variety, timelessness, functionality, and good and poor points or uses of the geometric patterns. The total length of history spanned by these six is not as great as the irregular examples, which fact may be significant itself.

Again, the same set of facts is given for each city, and these facts are likewise only the very basic ones for our purposes.

The cities, as they appear, are:

Pompeii

Annapolis

Savannah

Washington

San Francisco

Canberra.

1. Pompeii (Fig. 31)

Location: Southern Italy

Period: Hellenistic – Probably sixth to first century B. C.

Type: Population made up of patrician and middle class, including wealthy merchantmen.

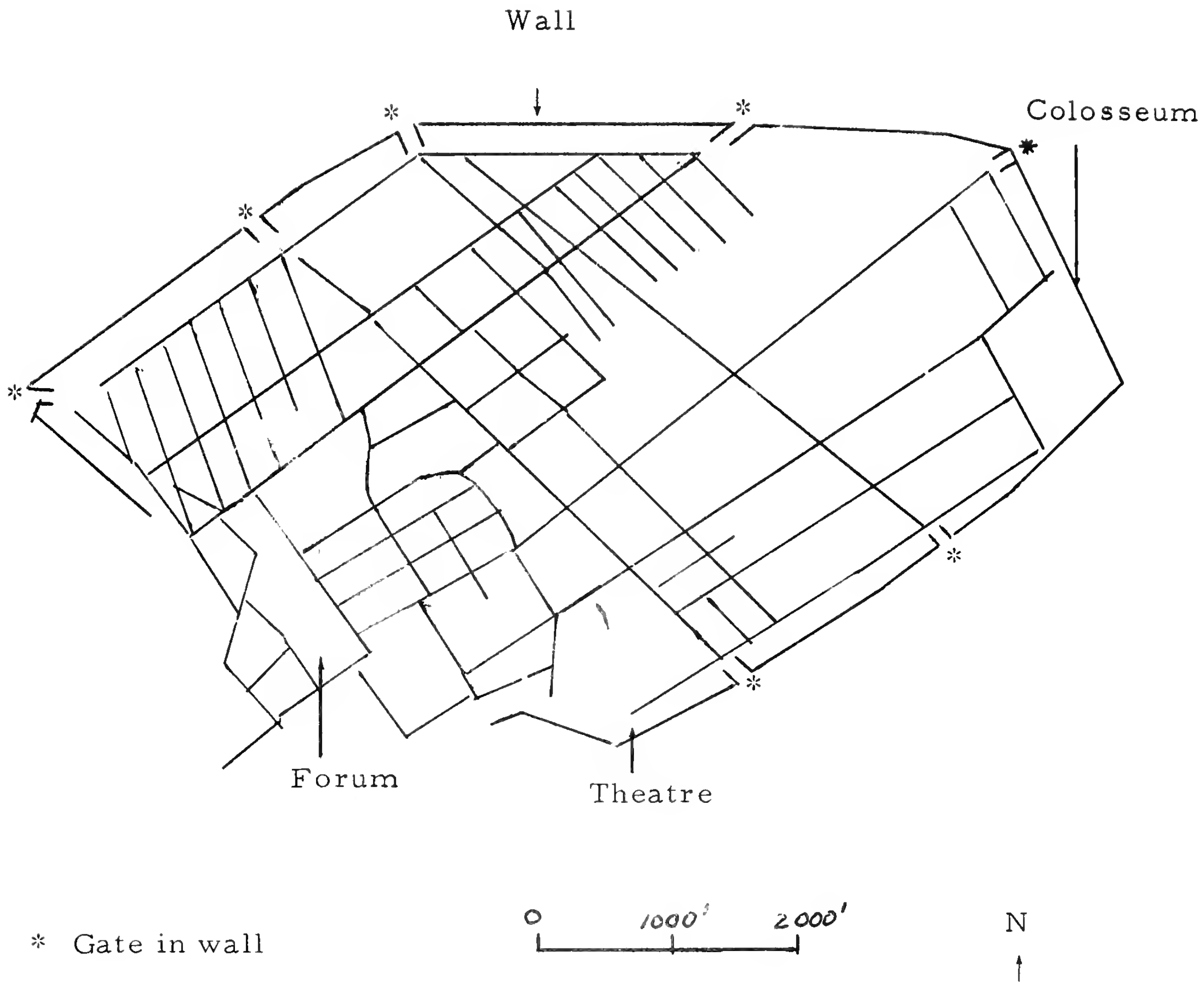

Figure 31
Pompeii

Population: 25,000 to 30,000

Traffic: Pedestrian and limited man-drawn, or animal-drawn vehicles

Pattern: A non-rigid grid

Remarks: Pompeii was built, rebuilt, and expanded during several periods of time, which accounts for the varieties of grid patterns observable.[1] It certainly shows the effect of planning, but not necessarily of stubborn rigidity. "No vehicular access was allowed in or near the forum areas, and gates were provided to prevent this if necessary."[2] Some small chariots were allowed for privileged persons. The business streets were 28 to 32 feet in width. Lesser roads varied from 12 to 18 feet. All were paved and provided with raised sidewalks. The city was a residential and recreational center, and the streets were evidently designed to give access from the houses to the forum and public meeting places. Streets were numerous, but narrow, so that the space they required was not excessive.

2. Annapolis, Maryland (Fig. 32)

Location: Middle Atlantic, Eastern United States

Period: Colonial America - Founded 1694

Type: Colonial capital

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1. Frederic R. Hiorns, op. cit. pp. 44-51, is an excellent source of general information about Pompeii.

2. Ibid., p. 48.

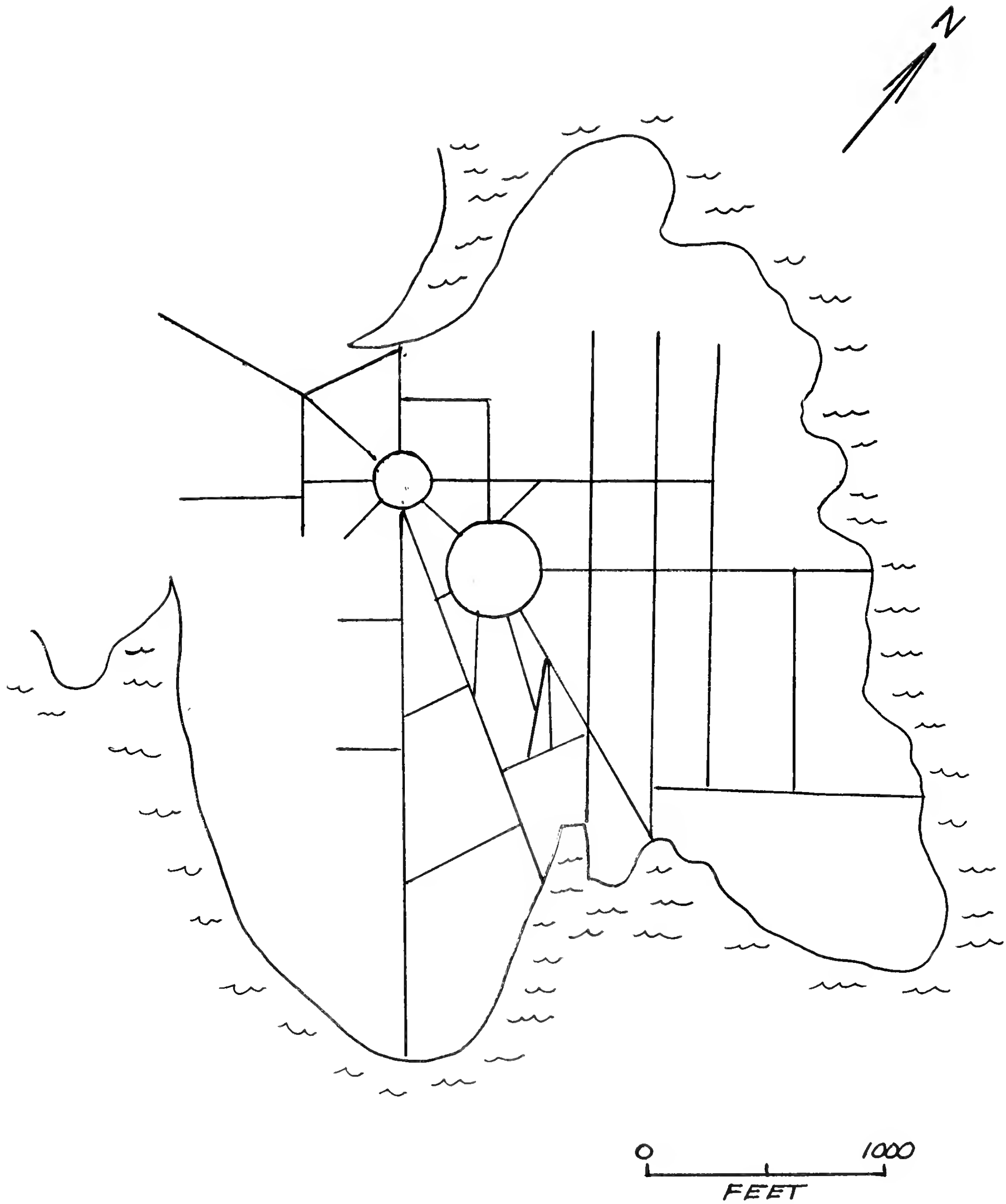

Figure 32

Annapolis, Maryland

Population: 20,000

Traffic: Pedestrian and Carriage

Pattern: Radial – American Baroque

Remarks: Annapolis was the first city in America to adopt the diagonal street plan. This followed from the European trends during this period. The main streets lead from the then busy water-front to the two foci of the city; the capitol building in the large circle, and a Roman Catholic church in the smaller one. (Maryland was established as a Catholic colony.) Streets are narrow and straight. The pattern is almost exactly the same today as it was originally, with the result that the automobile congestion is unsurpassed by any town this size.

3. Savannah, Georgia (Fig. 33)

Location: South Atlantic, United States

Period: Colonial America – Founded in 1733 by Oglethorpe.

Type: Colonial commercial and capital city

Population: Now 180,000

Traffic: Pedestrian, wagon and carriage; now automobile and pedestrian

Pattern: Grid

Remarks: Savannah, as its name implies, is located on a high,

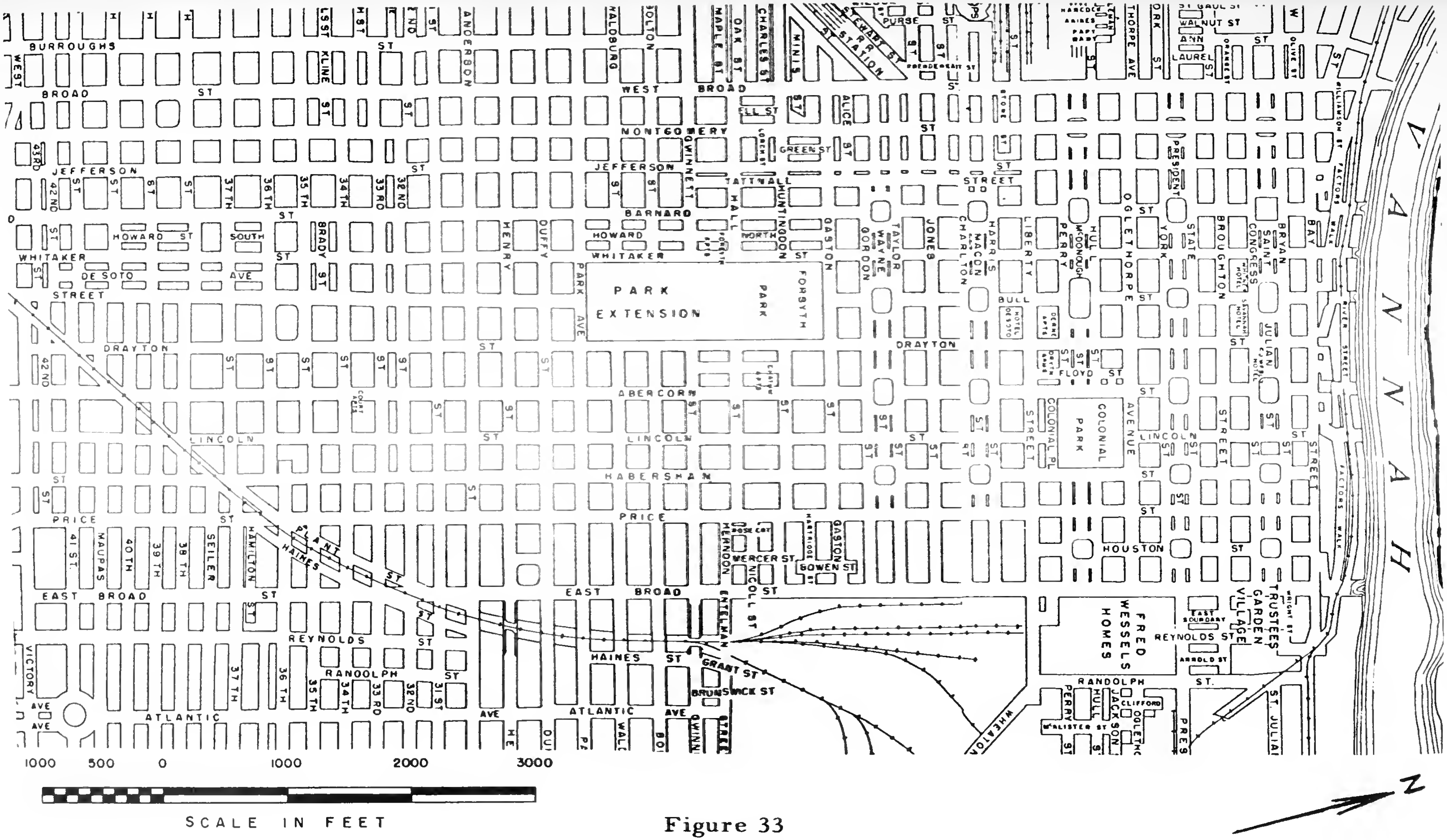

Figure 33

Savannah, Georgia

(From D.A. Byck & Company, Savannah, Georgia; 1954 Map of Savannah.)

flat area in the midst of extensive marshlands, on a bluff of the Savannah River. The grid pattern still functions well in this city. In fact, this may be the best example of the correct variety and use of the grid pattern known. There are several reasons for its continued success:

a. It is on relatively flat terrain, creating no problem of grade.

b. Land use density is reasonably low because the city is not of metropolitan size, hence the traffic strain is only moderate.

c. A mixture of business, school, park, and residential land use gives a pleasant variety to the plan.

d. There is an abundance of trees throughout much of the city.

e. Streets are of various lengths and widths. Added variety in widths is obtained by selected restrictions on parking and two-way travel.

f. Through traffic can by-pass the central part of the city. A large amount of space goes for street right-of-ways, but only a part of this is for vehicles, the rest forming wide sidewalks and open space for trees and grass. The original pattern of 1733 remains and has adapted very well to the automobile age.

4. Washington (Fig. 34)

Location: Middle Atlantic, United States

Period: "The Young Republic"; founded 1790-1800

Type: National Capital

Population: Now almost one million in District of Columbia

Traffic: Originally horse and carriage and pedestrian

Pattern: Radial over grid

Remarks: President Washington commossioned L'Enfant to draw up plans for the capital city of the new nation on the banks of the Potomac. L'Enfant was an ardent admirer of the Baroque cities of Europe, and so thought it fitting that this new-born republic should have an impressive city plan for its capital. L'Enfant was very much concerned with reciprocal views, so that a person could obtain a magnificent and impressive vista down a street toward a great public building in either direction. His streets were overly generous in width and length, and it was not until the city grew to the half-million mark and the automobile filled these routes, that their full capacities were realized. Various spacing of the grid streets can be noted. The intersections of radials and grids produces quite a number of useless, odd-shaped pieces of ground. In spite of the lack of a rapid transit system in the city, it serves the modern automobile requirements very well to this day.

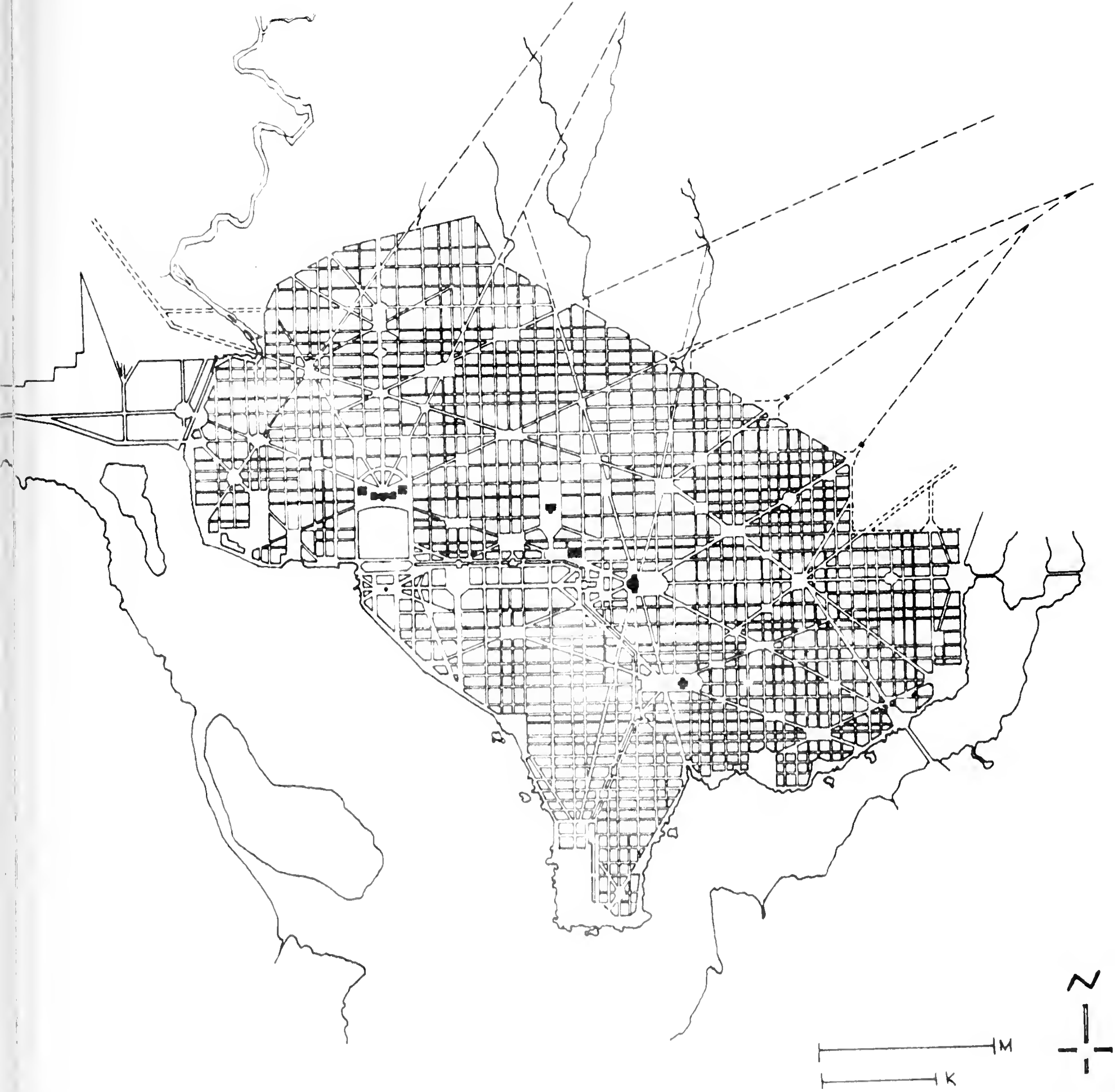

Figure 34.

L'Enfant's Washington
(From Richard Wurman, op. cit.)

5. San Francisco (Fig. 35)

Location: Pacific Coast, United States

Period: Founded in mid-1800's

Type: Commercial

Population: In 1870: 150,000

Traffic: Originally wagon, horse-drawn trolley, pedestrian

Pattern: Grid

Remarks: San Francisco is perhaps the best-known and most-cited example of how not to plan a city. Its gridiron pattern is almost nowhere compromised by the hilly terrain it covers. As a result the grades of many of its streets are among the steepest found in any large city. Yet, for all of this, San Francisco is today one of the most interesting and exciting cities in the world, San Francisco was laid out by a surveyor named Jasper O'Farrell in 1847. O'Farrell is said to have favored a street pattern adapted to the terrain, but landowners insisted on a grid pattern because they felt this scheme would make their lots worth top prices. Streets are practically all the same width, except for Market Street, which separates the two main grid sections of the city. Market Street is the main street of the city, 110 feet wide, and it extends from the waterfront all the way to Twin Peaks, several miles across town. After the earthquake and fire of 1906, San Francisco had an opportunity to remake itself along different lines, but for reason of finances and time, the city quickly reappeared in the same pattern.

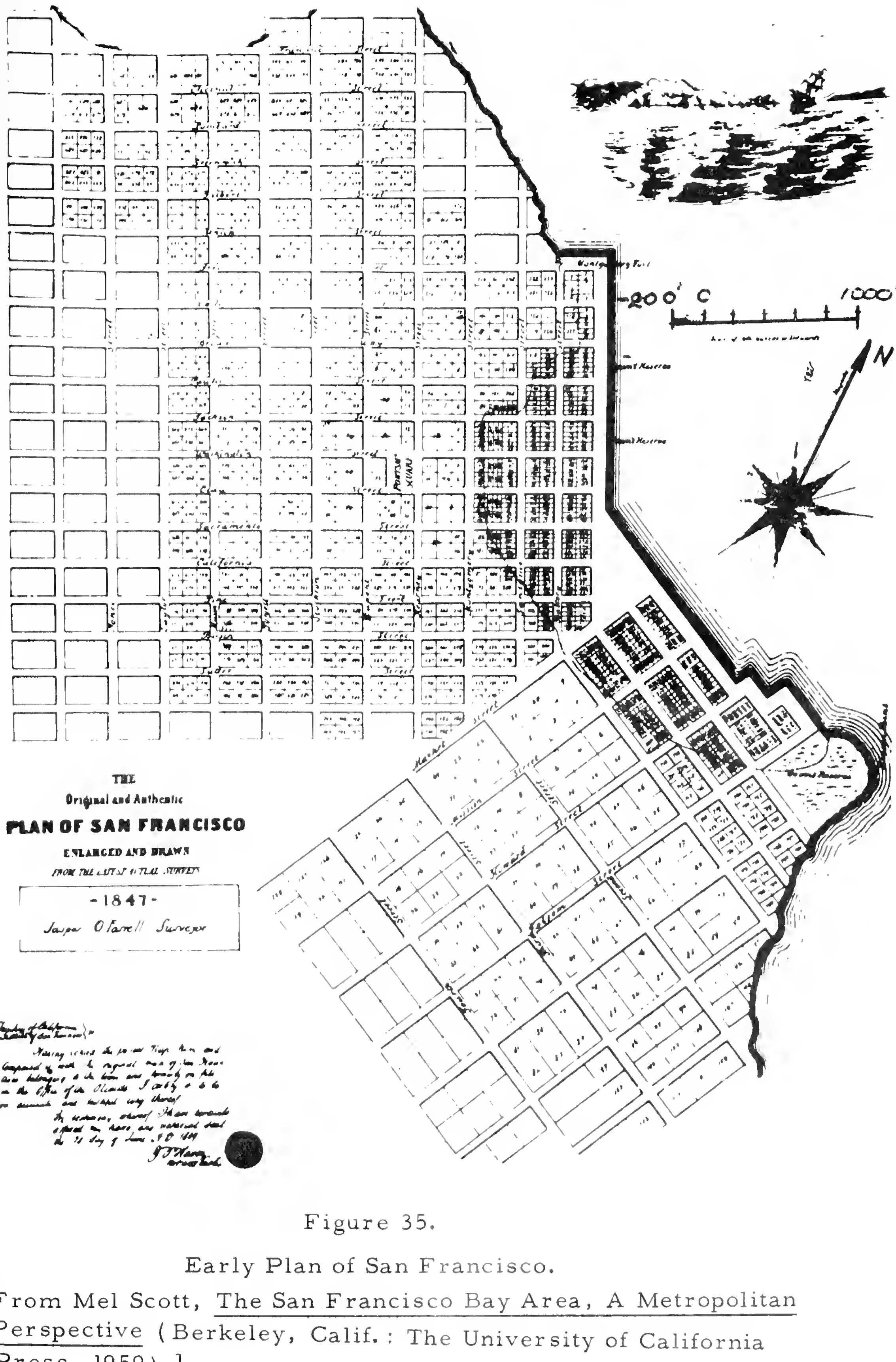

Figure 35.

Early Plan of San Francisco.

[From Mel Scott, The San Francisco Bay Area, A Metropolitan Perspective (Berkeley, Calif.: The University of California Press, 1959).]

Streets consume about twenty five per cent of the developed land area. Land use in much of the city is unrelieved by parks or open spaces.

6. Canberra (Fig. 36)

Location: Southeast Australia

Period: Modern – Founded 1911 – 1920 period

Type: National Capital

Population: In 1959: 44,000; Planned for 150,000 to 200,000

Traffic: Automobile and truck

Pattern: Radial

Remarks: Canberra was chosen as the site of the new Australian capital in 1911 and invitations for plans were issued. That of a Chicago architect, W. B. Griffin, was selected. Fig. 36 was his approximate design, although the city today has not yet grown to include some of the outer groups of radials. The city spans a wide river with several bridges. The main axis, Commonwealth Avenue, runs north and south from Capital Hill to the Civic Centre, a distance of about two miles. The hexagonal appearance is produced by the supplementary street system, which is actually an awkward attempt to join eight separate grids oriented in eight directions. The system apparently works satisfactorily now, but one can imagine the bottlenecks that will evolve because of the bridges and round-points being overloaded when the city reaches maturity. The site is

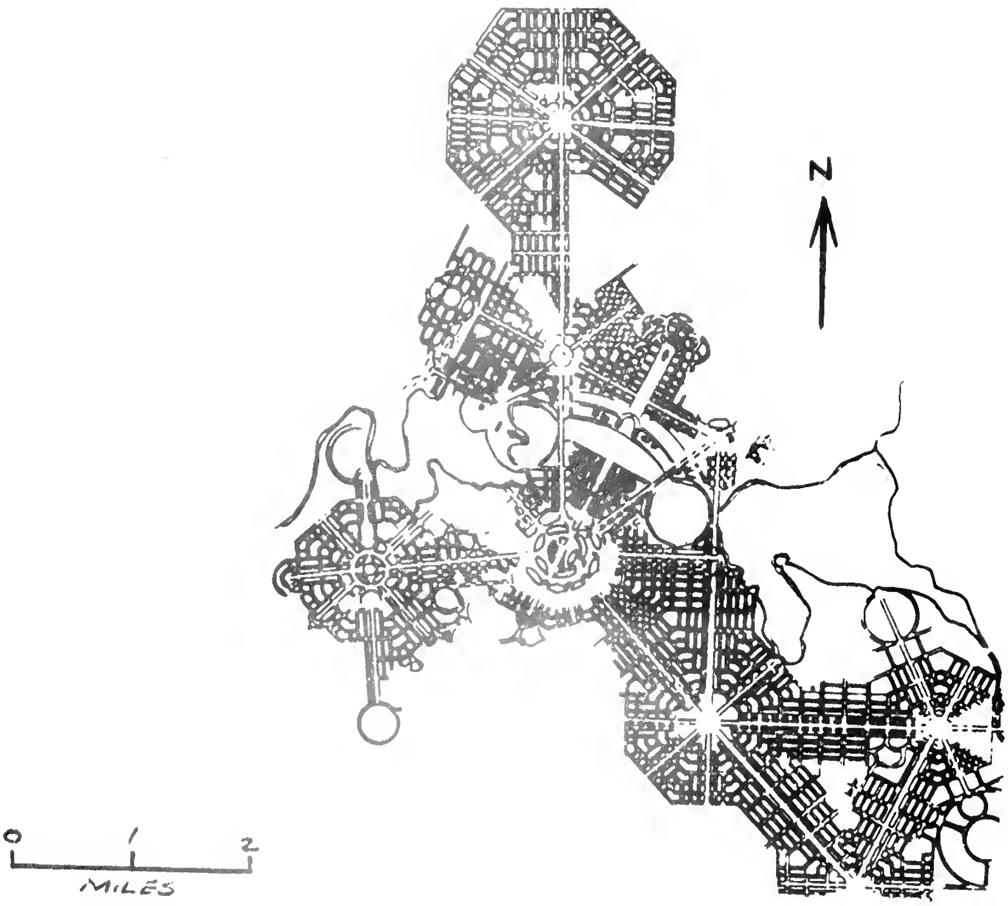

Figure 36.

Canberra
(From Richard Wurman, op. cit.)

reportedly very attractive, lying on a plain between low mountains. The roundpoints are placed on gently rising conical hills.[5]

Geometric patterns appeared in cities after irregular patterns, and may be survived by them, also. Though the grid and the radial patterns have proven to be useful and superior in some cases, there is currently a studied avoidance of them in modern planning. This could be a temporary period, but it may last for several generations. The following facts can be obtained from a study of geometric patterns:

1. Careful planning is especially required in geometric patterns, lest the symmetry of geometry overshadow the function of the streets. No planning at all would have been preferable to the sterile and unimaginative patterns developed in some cities.

2. Grids can be made adaptable because their parts are interchangeable. There are many choices which can be made among streets and blocks as to traffic and land use.

3. Geometric patterns generally use and waste more land area than irregular patterns.

4. Geometric patterns are more prevelant in the United States than in other countries.

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5. Information taken primarily from Griffith Taylor, op. cit., pp. 358-363.

PART IV

EVALUATION

A summary of the preceding chapters and the impressions and conclusions that follow from them.

CHAPTER TEN

SUMMARY AND CONCLUSIONS

When cities were new, and the function of circulation did not occupy such a position of moment as it does now, conditions were generally satisfactory. The combination of small cities, low volumes of movement, and pedestrian modes of transportation meant that almost any arrangement of open spaces would serve the purpose. The demands upon streets were modest, and often their structure reflected this. Streets were used for many and various purposes and they took on many and varied kinds of patterns.

As cities grew larger and as transportation became more sophisticated, the circulation activity in cities increased manyfold. Unfortunately the streets of the old cities were unable to grow accordingly. The consequence has been a stifling condition of congestion and loss of efficiency. The entry of motor vehicles into cities that were meant for people brought conflict--the two were incompatible.

A key reaction to this situation was the commencement of city-building on a new scale; the scale of the automobile instead of the man. The spread city of residential, shopping and industrial areas joined by long, wide arteries, composed of and separated by vast expanses of space, is the response that has been made to this problem. Possibly, though, another choice was open: a return to the pedestrian scale within

the neighborhood or the central business district or other integral area of a city. Perhaps eventually we will make this choice. Men may one day celebrate their independence from the automobile.

Streets, after all, are only servants of people, supposedly designed to allow the public to move about as harmoniously, efficiently and safely as they can. This should not necessarily involve the blanketing of our environment with automobiles and their routes. This means that instead there should be a variety of patterns to meet a variety of needs in optimum fashion. The primary function of circulation itself can take many forms; long and short distance, fast and slow speeds, direct and circuitous routes, individual and mass movement, casual or purposive travel. Nor is circulation the only function performed by streets. Its secondary capabilities are also important and varied and should be given proper consideration in the evaluation or design of the street system.

In order for a street system to be successful, it must be useful, economical and attractive. A street system that is misused certainly is not being as useful as it could be. Similarly, a street pattern that requires an excessive amount of money, land, and operating expenses is not really successful. It may carry high capacities of traffic and allow fast speeds, but it is not a good street pattern. The question of appearance is as important as any other, especially in a world of growing bigness and crassness. We must

take special care of the esthetics of the environment, for they are vital to our lives to an extent which cannot be measured.

Spaces and the relationships among spaces that men live in are now a crucial factor. In primitive and pre-industrial days, space was an accepted and ample commodity. In modern life, space must be conserved and cared for. An awareness of the use that we make of closed and open spaces will bring an appreciation for the need for an apportionment between them. Both are needed for life. Open spaces can be considered in a hierarchical typology, classified according to the type of movement that occurs in each category. A balanced amount of each is needed, and a separation of them for the sake of optimum functionality, safety and comfort is desirable.

All street patterns are made up of several basic elements which can be varied. This is what makes it possible to arrange street spaces in so many different ways, resulting in a number of divergent patterns. Width, length, grade, curvature, orientation, number of intersections, number of streets in an area, distance apart, surface of the roadway--all are capable of differing among street patterns. In addition, the land use, facade and traffic load give streets their character without affecting their physical dimensions. With so many independent variables that are potentially capable of being controlled, the task of matching circulation requirements with street patterns can be subject to intelligent control.

The problem is not one of simply manipulating these items to come up with the scientifically-optimum street pattern, however. There are a number of outside influences tending to shape the street and the pattern of streets in an area which must be considered. The topography, geology, existence of natural and man-made obstacles, technical level of development of the society and prevailing estethic values are some of the factors that help to shape the street pattern. These can limit, or be used to advantage in the design and use of streets.

Street patterns are of two types, chronologically: pre-automobile and post-automobile. We try to use motor vehicles on both of these and it causes great consternation to find this an imperfect endeavor. Until recently the post-automobile patterns were very much like their predecessors because the habit of building streets for pedestrians and slow-moving, occasional vehicles was deeply ingrained. Lately there has been a break away from this custom, however.

Street patterns are of two types, physically: irregular and geometric. An analysis by these categories shows that each can be appropriate for certain circumstances. The irregular type is probably the oldest and the most widespread, but the geometric is by no means young or insignificant.

Irregular patterns are characterized by their lack of

repetitive relationships. With, curvature, length, distance apart, and orientation are highly variable. Many primitive irregular patterns were wide open spaces interspersed with isolated, temporary structure. These settlements should not really be called cities, however. Their populous was small and undifferentiated. Agriculture or hunting and fishing were the main occupations. Ancient cities of the fifth through the second millenia, B.C., were often of a shattered irregular pattern. The separation of enclosed and open space was hazily defined. Circulation was not the pre-eminent, dominating activity of the street. Medieval streets were clearly defined, but tortuous and irregular in the truest sense of the word. Lastly, modern irregular patterns have returned as planned, deliberate systems.

Geometric patterns usually have straight streets of constant width and their relationships are repeated throughout the system. Street lengths, distances between intersections, blocks sizes and shapes, orientation are prone to be alike. The main streets of some ancient cities show geometric characteristics, but the first use of this pattern for a city-wide arrangement was during the classical ages of Greece and Rome. The geometric pattern next made an appearance during the Renaissance. This was the hey-day of the radial pattern. At about the same time the grid pattern developed into popularity. Many colonial towns were started and continued with

this pattern. In America the system of rectangular land surveys of the public lands across the continent reinforced this manner of platting cities. The geometric pattern as a reaction to the natural and organic appearance of the earth shows signs of subsiding, perhaps, but not of disappearing.

We can reach some tentative conclusions about street patterns from this survey of cities, spaces and routes. Tentative, because they have not been subjected to a rigorous testing by mathematical analysis, or by a penetrating investigation in any one city. Rather, they are the findings that one is disposed to acknowledge after an exposure to a sampling and generalizing process.

As for traffic, it appears that streets should be used for their original purposes for maximum benefits. A main source of trouble in city streets today is that they are used, but not designed for large volumes of automobile and truck traffic. The motor vehicle is not being used advantageously and the city suffers when open spaces--circulation routes--become clogged with conflicting and ineffectual vehicles. Powerful means of transportation are wonderfully suited for inter-community travel and for mass motion, but their advantages are nil for individual movement over short distances. Old city streets, and many new ones, are laid out for low velocity, individual type traffic. Large volumes of this type traffic

can be moved efficiently when not packaged in large, unwieldly metal boxes. On the other hand, new patterns that are originally planned for large volumes of automobile traffic, as on limited-access highways, are evidence that a matching of the design and the traffic can result in a successful pattern.

There should be a greater reliance on the pedestrian mode of travel for intra-community business. In crowded areas, for short trips, the pedestrian can move faster and with less conflict than can vehicles. Not only would this free the pedestrian-designed street patterns from strain, but would save travelers' money otherwise spent on operating expenses of vehicles.

Cities should exercise control over the numbers and types of traffic that use streets. This is being done on a very limited scale by use of one-way streets, prohibition of trucks from certain streets, and restrictions on parking, but the actual turning away of automobiles beyond a given volume in an area has not yet been tried.

As for street patterns several points stand out.

First, it seems that we should admit of the finiteness of the effects of street patterns. Examples of cities, neighborhoods and communities whose esthetic qualities and circulation activities exhibit extreme varieties within similar patterns attest to the presence of many other factors at work. We should not attach indue importance to the street pattern itself. The indirect elements--surrounding land use, street facade, and traffic--can ruin a good pattern and mitigate

the effect of a poor one. Streets do not make a city.

Second, both irregular and geometric street patterns have long histories, and possibly long futures. Both have been found in several different periods of history, and each dates to ages thousands of years ago. Although there may be wide differences within categories, and over the years, it is still true that irregular and geometric patterns, based on the elemental characteristics of streets, can be classified this way. Aside from any advantages or disadvantages that either may possess, each continues to exist and to be built. Whether for rational or irrational reasons, irregular and geometric patterns appear destined to endure.

Third, the irregular pattern has much to commend it to the city's use. It can be made to fit the purpose of the community and the topography of the area. It allows for an intelligent and economical use of land, and provides relief from monotony. Streets can occur in the sizes and shapes that are functionally determined. The scale of the system can shrink or expand without appearing distorted or discontinuous.

Fourth, geometric patterns are satisfactory but they have been typically misdesigned and misused. The grid can require heavy amounts of space. It can lead to monotony. But, it can also work very well on level terrain, and when tempered with variety in distances, lengths, widths, abutting land use and vegetation. The radial

system by itself is insufficient as a street pattern, but when supplemented with other patterns between the diagonals, it is for focusing mass traffic upon a central area. It is primarily a long distance pattern. Geometric patterns have the advantage of user-orientation, which makes the tasks of travel and location easier.

Finally, modern technology and ideas give men the opportunity to create street patterns of new dimensions. We have the engineering knowledge and the financial resources to overcome problems of time and space that heretofore presented insurmountable obstacles to city-building. Our streets can be planned far ahead, over vast areas. We can comply with nature's dictates when it suits our purposes, or alter and overcome its deficiencies when necessary. We have the ability to map out communities, move earth, build bridges, and landscape the topography to extent never before possible. The experience that we have gained with cities and with vehicles give us new ideas about circulation functions, and can lead to better solutions. The separation of different modes of traffic, the wiser use of space, the use of the vertical dimensions and many other concepts can build upon, and be improved by, the experiences of the past. Twentieth century progress in the field of electronics also opens new possibilities for our street patterns. Electronic communications

should be exploited more intensively as a substitute for physical movement of people and goods. Information and ideas are the only products what most workers produce today. Much of this kind of product can be produced in a home workshop and transported by electronics. Though face-to-face relationships will never be completely obviated, there is opportunity for this kind of substitution in certain cases. This invisible "street" pattern could become more important than any other in the future. Thus, we are on the threshold of an age in which entirely new patterns can be built, based upon past experience, engineering ability, and modern communications. Whether we shall so build, or what form these patterns will take, no one can say.

In summary,the conclusions are these:

1. Structures and functions in the city that are not a direct part of the street pattern can have a great effect on the quality of a pattern.

2. Irregular patterns have many natural advantages and enjoy continued popularity and functionality.

3. The grid pattern is potentially good, but it has generally been poorly and unimaginatively applied.

4. The radial pattern is good for large areas and long distances, but must be accompanied by other patterns for smaller scale activity.

5. The means are at hand for street patterns with new elements and at new dimensions.

APPENDIX

The author is a member of the Civil Engineer Corps, United States Navy. Civil Engineer Corps officers have responsibility for the planning, design, construction and maintenance of the Navy's shore facilities. Each year several CEC officers are sent to various civilian and military educational institutions for the purpose of improving their ability to perform their Navy jobs. In this way the Civil Engineer Corps takes advantage of the continuing advances in knowledge and technology originating in the academic environment, and allows its officers to add breadth and depth to their backgrounds. Considerable lattitude is permitted these officer-students in their choice of schools and curricula; the major stipulations being simply that the education be in a field pertinent to Navy needs, and that it be of a calibre comparable to a graduate degree program. The author chose Princeton University, the field of planning, and the following curriculum:

Course	Department
SUMMER 1963	
Mathematics Topics for Engineers	Civil Engineering
Structures (Audit)	" "
Soil Mechanics (Audit)	" "
Readings in Urban Sociology	Bureau of Urban Research

Course	Department
FALL 1963	
Port and Harbor Engineering	Civil Engineering
Industrial Relations and the Social Order . .	Sociology & Anthropology
Urban Sociology	Sociology & Anthropology
State and Local Government	Politics
SPRING 1964	
Transportation Engineering	Civil Engineering
Community Planning	School of Architecture
Problems in Modern World History	History
Thesis	Bureau of Urban Research

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